Popular Astronomy.

Vol. IX No. 10. DECEMBER 1901. Whole No. 90

THE TOTAL ECLIPSE OF THE SUN IN SUMATRA.

E. E. BARNARD.

FOR POPULAR ASTRONOMY.

THE EXPEDITIONS.

In the total eclipse of the Sun this year on May 18, the shadow of the Moon first touched the Earth at sunrise near the south end of the island of Madagascar. It moved rapidly eastward, and passing over the island of Mauritius it crossed the long stretch of the Indian Ocean not again touching land until it reached the west coast of Sumatra at the town of Padang, at which point it arrived near noon. Crossing Sumatra it passed over the China Sea and across the island of Borneo, and over the Celebes to the coast of New Guinea whence it left the Earth at sunset.

There was little enough available land along the shadow path and Sumatra seemed to offer the best chance to observe the phenomenon. Borneo was too little known to trust oneself far from the coast and the weather conditions were also uncertain.

The long duration of totality in this eclipse—six and a half minutes on the central line—offered such an opportunity for the study of the corona as had not occurred since photography has lent its subtle power in dealing with the coronal mysteries. Advantage was taken of this extremely favorable chance by several of the leading nations. The English, American, Russian, Dutch, French and Japanese were represented. Germany alone had sent no expedition.

Sumatra seemed to be the main point for observation and to it went two English and three American parties, a French, a Japanese, a Russian and a very big Dutch party. Also a party of Jesuits from Calcutta. An English party under Mr. Maunder was located far to the westward on the island of Mauritius. Professor Todd was stationed on the island of Singkep, south of Singapore. It seems that the larger portion of the observers were located at or near Padang on the west coast of Sumatra.

Clouds interfered more or less at all the stations except one—and that one where the chances of clear weather were the poorest.

One of the largest and best prepared expeditions which went to Sumatra to observe the eclipse was sent out by the United States Government from the Naval Observatory under the charge of Professor A. N. Skinner. This consisted of six astronomers from the Naval Observatory and five invited astronomers who became members of the expedition by courtesy of the Government. The expedition carried with it some fifteen tons of instruments. A complete list of the members of this expedition follows:

A. N. Skinner, in charge.	W. W. Dinwiddie
W. S. Eichelberger	G. H. Peters
S. A. Mitchell	F. B. Littell
W. H. Humphreys	H. G. Curtis
N. E. Gilbert	E. E. Barnard
L. E. Jewell	

Through the great kindness and courtesy of Professor S. J. Brown, the director of the Naval Observatory, I became a member of this expedition.

Through the kindness of Professor Hale, I was able to take with me from the Yerkes Observatory the photographic outfit used at the total eclipse at Wadesboro, North Carolina in May, 1900.

Another member of the party who did not go with the expedition, was Mr. Rene Grainger, of Georgia who went to Sumatra by way of Europe at his own expense and who arrived at Solok a few days after we did to become a member of the expedition, and proved a valuable help.

There was a second expedition from the Smithsonian Institution in charge of Mr. C. G. Abbott which consisted of Mr. Abbott, and Mr. Paul A. Draper. These two expeditions journeyed to Sumatra together, were located at the same station, Solok, and returned together.

The Journey.

The expedition, or expeditions, left San Francisco Feb. 16th on the U. S. Army Transport Sheridan, Captain Pierce, for Manila, P. I. After a rough voyage of nine days Honolulu was reached. Three days were spent here in this justly called "Paradise of the Pacific." The members of the expedition were under many obligations for the kindness shown them by the scientific people of this city, which made the rest there of more than usual interest.

From Honolulu to Manila the voyage was very delightful. The Sheridan arrived at Manila at 10 P. M. of March 18th. The expedition was delayed here one week awaiting transportation to Sumatra. While at Manila a visit was made to the Jesuit Astronomical and Meteorological Observatory where the utmost courtesy was shown the members of the expedition by Father José Algué, the director. This Observatory is doing very valuable meteorological work. The study and prediction of typhoons —so destructive in the China Sea, and of which Father Algué has made a special study—is of the utmost importance to navigation. The work was spoken highly of by the officers of the various vessels on which the expedition sailed. The Manila Observatory is equipped with a fine refractor of 19 inches aperture; the object glass being by Steinheil and the mounting by Saegmuller. On account of the troublous times of the past three years the object-glass had been removed and hidden away during that period and hence the telescope was not in condition to be used while we were in Manila. Father Algué stated that they had a large percentage of clear nights during the year and that the atmosphere was steady much of the time.

The United States gunboat General Alava, Captain Halsey, was assigned the duty of transporting us to Padang and on the evening of March 26th, we sailed out of the bay of Manila through the south channel by Corrigidor, and turned southwards toward the equator. This journey was a most interesting one of nine days duration. From the Philippines we passed along the full extent of the west coast of the island of Borneo, through the Strait of Sunda up the west coast of Sumatra to Emmahaven the harbor of Padang.

On March 30th, going South, we passed the Sun and at noon it was only four minutes of arc from the zenith!

Krakatoa.

During the whole of the second of April we were passing through the Strait of Sunda and from early morning until darkness cut off our view we were in sight of the island of Krakatoa, passing south within a mile of it at about one P. M.

Nothing in the entire journey was perhaps so interesting as this remnant of a mighty catastrophe that blew away three-fourths of the island and destroyed 40,000 to 50,000 lives in 1883, and which sent a tidal wave several times around the Earth and filled the Earth's entire atmosphere with volcanic dust for several years. The splinter of the original mountain that now

remains is very steep and rises to a height of 2,677 feet. It is very abrupt and precipitous on the north side where the explosion occurred and the whole southern slope is scarred and seamed with numerous small ravines, and cracks. At the base there is, on the south side, a slight beach along part of which a few trees resembling evergreens were growing, several small palms were seen near the water. The slopes everywhere seemed to be covered with a kind of grass that appeared to be filled with a whitish blossom. A few stunted shrubs were seen as high as half way up the mountain. The glimpses of the northern side showed the precipitous surface to be of a reddish volcanic color. On that side the crater lies far below the surface of the ocean and it is said that bottom had not been touched at 140 fathoms. In Sumatra we were told by one of the scientific men from Java that the director of the botanical gardens in Java makes an annual visit to Krakatoa to study the development of new life upon it. In the region of Krakatoa great areas of pumice stone were encountered floating about on the water which were perhaps washed away from Krakatoa by the waves, as a portion of the base of the island to the southeast seemed to be under process of destruction by the surf.

As we approached Krakatoa there was a splendid cloud cap above its summit, producing the realistic effect of an active volcano. A number of photographs were secured of the island and an admirable series of accurate sketches made by Mr. Jewell, who is very skillful at sketching.

Arrival in Sumatra.

The General Alava arrived at Emmahaven at four o'clock on the afternoon of April 4, but we did not land until the next day. That morning when we waked we found that a Dutch steamer had arrived during the night and to our great pleasure Professor Perrine and his outfit were on board.

Emmahaven is connected by rail with Padang, which though on the coast itself, does not have deep water. A ride of 20 minutes brings one to Padang which is quite a large place at the mouth of a small river.

On the afternoon of the 6th several of the party, including Professor Skinner and the writer, took the train for Fort de Kock which lies at the base of the great volcano Merapi. At this place we spent the night. The next morning Mr. Abbott and I left on the early train for Solok, a four hours' journey, part of which was along the shore of Lake Singkara and all of which

E. E. Barnard, Photographer.

KRAKATOA FROM THE SOUTH.

The clouds are natural and are not volcanic smoke.

E. E. Barnard, Photographer.

KRAKATOA FROM THE SOUTH.

(The clouds have unfortunately been "doctored" in the engraving.)

E. E. Barnard, Photographer.

KRAKATOA FROM THE SOUTHWEST.

E. E. Barnard, Photographer.

KRAKATOA FROM THE SOUTHWEST.

The explosion occurred to the left, behind, where the slope is precipitous.

was through a country beautiful in the extreme. At Solok we called on the Dutch vice resident, Mr. Derx, who offered us every courtesy. We selected an old unoccupied fort at the northwest edge of the town which was surrounded with a rampart and a moat and numerous lines of barbed wire fencing, as a fit location for our instruments. The Fort had a long barracks building consisting of one very large room with several smaller ones at the ends. These had splendid cement floors. There was also inside the fort a powder magazine which we converted into a dark room.

If everything had been planned and laid out for us beforehand no more suitable arrangements could have been had. The large room served to store the freight and to prepare the instruments, and when some cots and mosquito bars were put up, served admirably also as a sleeping place for some of the party; the small hotel, kept by a Malay woman, proving inadequate in sleeping accommodations.

SOLOK.

Solok is a small village beautifully situated in a wide valley amidst groves of cocoanut palms, at an altitude of about 1,300 feet above the sea, and in latitude 0° 47′ south. To the south several miles distant is the volcano Talang which has not been in action for some four years. A small river winds along the west side of the town beyond which a couple of miles away is a range of high hills, and to the east is a similar range of hills, while the valley opens out to the north in the direction of Fort de Kock. It contains an excellent railway station, a native market and two bridges. There are two excellent streets (without sidewalks) which are always in first class condition—a feature specially noticeable everywhere in reference to the roads in Sumatra. There are some very comfortable residences on the main streets occupied mainly by half casts, a mixture of Dutch and Malay. There are not above half a dozen pure white people in Solok. These consist of the vice resident, two school teachers and several others, all connected with the government service. The rest of the population is native Malay, whose homes are extremely picturesque, if not overly clean on the inside, and a number of Malay-Dutch. The natives in general seem to be a fairly good sort of people. The mixture of Dutch blood with the Malay has made a fine looking class of people. The men are educated and manly and the women are often beautiful. The natives are Mohometans, though not of the fanatical kind. They have a rather handsome Mosque across the river from Solok.

There are two good schools in Solok, one for the native children and the other for the children of mixed blood.

Solok has a native police system whose main business seems to be to strike the hours of the night on various hollow masses of wood, pieces of railroad iron, etc., at certain stations distributed about the town. There is also situated at this place a large prison whose inmates work out on the roads and do other menial labor unguarded, and whose only fear seems to be that they will not get back to prison before 5:00 p. m., after which hour they would be locked out all night.

There is one small hotel kept by a native Malay woman, the widow of a Dutchman.

The valley in which Solok lies is very fertile and is largely cultivated in rice.

The Flag of Holland and the Flag of the United States Float Together over the Old Fort.

Professor Skinner was detained several days at Fort de Kock arranging for the location of one part of the expedition at that point. But when he arrived at Solok he heartily approved the choice of the fort for our station and the freight was at once shipped to Solok and was soon stored away safely in the main building. Unpacking was at once begun, as was also the process of erection of the various instruments, etc.

Every courtesy was shown us by the Dutch. Our freight was transported free on the railway and we were given passes covering every portion of the railroad. A great number of prisoners were put at our disposal for the carrying of the freight from the railway station to the Fort.

We asked permission to fly the United States flag over the entrance to the fort which was courteously granted. As a return for this courtesy we asked the vice resident to lend us a Dutch flag so that the flag of Holland should float with our own over the old fort. This pleased him very much, and he sent an enormous Dutch flag, beside which our own was but a small affair, but its modest stars and stripes pleased our hearts none the less for all that.

Additional Stations.

To lessen the chances of total failure from clouds Professor Skinner had sent out two parties to occupy stations elsewhere. One of these consisting of Dr. S. A. Mitchell and Mr. René Grainger and a marine from the gunboat, was located at Sawah-Loento

on the railway to the east of Solok. The other party consisting of Professor Eichelberger, Dr. Humphreys and Mr. Peters went to Fort de Kock on the railway to the north near the volcano Merapi.

This last party was near the northern edge of the path of the shadow. The meteorological reports of the Dutch government gave little promise of a clear sky at Fort de Kock, perhaps less than for any of the other stations occupied. On the day of the eclipse, however, it was the only eclipse station in Sumatra that had a perfectly clear sky. Excellent photographs were obtained of the corona at this point with the 40 foot coelostat by Mr. Peters. At Sawah-Loento some results were obtained by Dr. Mitchell though clouds more or less interferred.

NEIGHBORS.

At Sawah-Loento were also located Mr. and Mrs. Newall and Mr. Wallace from Cambridge, England. It was one of the pleasures of the stay at Solok to frequently meet them for a few minutes at the station on their way to or from Sawah-Loento. We also had the pleasure of meeting Professors Burton and Smith and Dr. Matthies of the Boston Technological Institute who were also located at Sawah-Loento.

I was located at Solok with the main party consisting of Professor Skinner, Mr. Jewell, Mr. Curtis, Dr. Gilbert, Mr. Littell and Mr. Dinwiddie with the addition also of Mr. Irving acting interpreter and two marines. With us was also located the Smithsonian party under Mr. Abbott, consisting of Mr. Abbott and Mr. Draper. Their outfit was a very sensitive bolometer for determining the heat of the corona, and four intra-mercurial planet telescopes. This last consisted of four 4-inch portrait lenses of 11 feet focus, placed on one equatorial mounting and so adjusted as to cover a region along the ecliptic of some 30° on each side of the Sun. With this instrument two sets of large plates some 22 x 24 inches in size were exposed, each set receiving 2 minutes exposure. Mr. Abbott's equipment was very perfect and it is such a misfortune that clouds prevented the successful use of his intra-mercurial planet telescope, as it certainly would have done much to clear the vexed question of the probable existence of a planet or planets nearer the Sun than Mercury. Mr. Abbott had done an excellent piece of work with a very great amount of labor. It seemed such a pity that it should all end in nothing except the consciousness of having done ones duty most thoroughly.

Preparation.

It is not possible here, nor necessary, to go into details of the work of each member of the expedition, I need only say that each one was thoroughly prepared, and should fate have given us a clear sky would have nobly performed his duty. I am personally indebted to every member of the party for the unselfish help they gave in the erection of my own somewhat extensive apparatus. Their own instruments were left untouched essentially until mine was safely on the way to completion. Especially am I indebted to Mr. Dinwiddie and Mr. Curtis and Dr. Gilbert for the most valuable help—the word help does not properly convey my meaning for they did almost the entire work of erection and their intelligent advice and suggestions were of the utmost importance.

I will confine myself to a description of my own instruments for photographing the corona and also for the detection of any intra-mercurial planet which might be within a few degrees of the Sun. Two of these instruments were portrait lenses of 3¼ and 6 inches aperture. They were of short focus and were mounted on a small equatorial telescope loaned for the purpose by Professor Ormond Stone. With these it was intended to secure the greatest possible extent of the fainter outlaying portions of the corona. Six exposures were made with each camera, the longest being one of two minutes.

The following were the exposures with these two instruments:

No.	Time. s	Plate.	No.	Time. s	Plate.
1	5	Cramer Crown	4	60	Slow Isochromatic (Cramer)
2	40	" "	5	15	Cramer Crown
3	120	Slow Isochromatic (Cramer)	6	20	" "

The aperture of the larger instrument was reduced to 4 inches and the other to 2 inches. The plates used with the larger lens were 10 x 8 and for the smaller 6½ x 3½.

The main instrument which had proved so successful at Wadesboro, North Carolina in the eclipse of last year, May 28th, was a horizontal telescope sixty-one and a half feet long which had a lens by Brashear six inches in diameter. From the peculiar construction of this instrument it is called a coelostat. It consists, besides the lens, of a perfectly flat mirror placed parallel to the Earth's axis and revolving westward by clock-work at one-half the speed of the Earth's rotation and which throws a horizontal beam of light through the lens to form the image of the eclipsed Sun on a sensitive plate exposed in a dark room over sixty feet

PLATE XX.

E. E. Barnard, Photographer.

THE ENTRANCE TO THE FORT, FROM THE EAST.

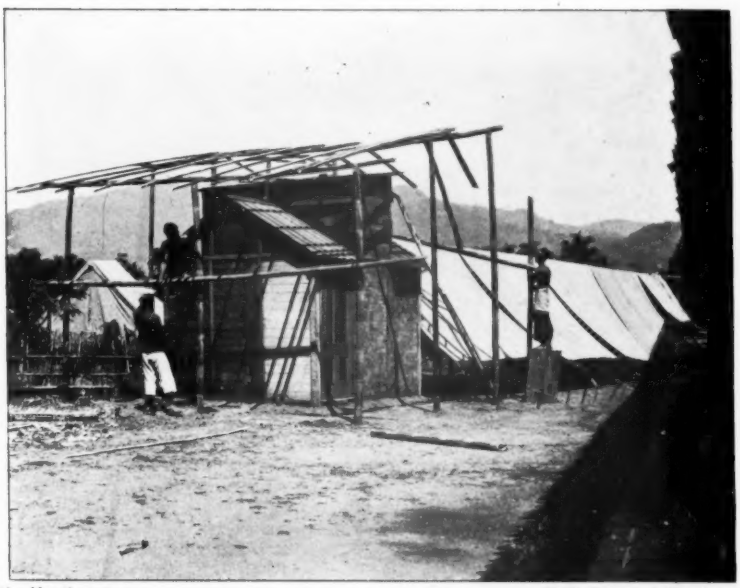
Mr. Draper is near the gate. The roof of the Coelostat house is seen close to the left at the base of the American flagstaff.

From the South.

W. W. Dinwiddie, Photographer.

Showing the Coelostat Tube and House.

In this picture the canvas tents have been removed from over the tube. To the left in the middle ground is the small telescope carrying the two short focus cameras. Near the middle of the picture is Mr. Curtis' Coelostat. At the end of the building to the left in the tall canvas house is Mr. Abbott's Intra-Mercurial Telescope. The large building is the one mentioned in text. The fence incloses the native keepers garden; to the left in this is sugar cane. The small trees to the right are the Papaja trees, bearing an excellent melon-like fruit.



From the Northeast. E. E. Barnard, Photographer.

THE COELOSTAT HOUSE AND TUBE.

Putting up the native roof as a shade to protect the house from the heat of the sun. The tube is covered by a series of tents.

From the North. E. E. Barnard, Photographer.

THE COELOSTAT, SHOWING MIRROR, LENS AND EXPOSING SHUTTER.

All of this except the mirror, was built on to the end of the tube, to the left, by black cloth, to exclude all light except what came through lens. This form of instrument was first suggested for eclipse work by Professor H. H. Turner.

away. The revolving mirror keeps the image of the moving Sun perfectly stationary. The present mirror was an excellent one 18 inches in diameter made by Mr. G. W. Ritchey. To insure that no irregularities in the motion of the mirror should injure the definition during the long exposures an electric control was attached to the clock-work. This controlled the motion every second of time. With this instrument the image of the Sun or Moon was seven inches in diameter and the details of the corona were on a correspondingly large scale.

From its very much greater focal length, the action of the coelostat is very much slower than that of the smaller instruments. This, however, could be compensated for in the present case to a certain extent by much longer exposure which the great duration of totality at Solok, 5 minutes and 52 seconds, would allow. What would be shown in a few seconds with either of the portrait lenses would take fully as many minutes to catch with the large one.

Though only the prominences and the closer, brighter portions of the corona could be secured in a few seconds with the coelostat, it would be possible with the longer exposures to get impressions of the fainter parts for over a degree from the Sun, an extent which had never been photographed on such a scale before.

The Large Plates.

On account of the great size of the image this would require an exceptionally large plate to contain it. After a consideration of the difficulties it was concluded that a plate forty inches square could be successfully handled, and would contain the more important features of the corona. So large a plate had never been used in astronomical photography. This plate—on plate glass—was made specially by the Cramer Dry Plate Company of St. Louis, and was given an exposure of two and a half minutes. On the diagonal this would cover four degrees of the sky, and the least width would be three degrees, so that coronal details on a very great scale could be expected to be shown over a space from three to four degrees in extent.

Besides this large plate, two other large ones, thirty inches square and five smaller ones of 14 x 17 inches were used during the interval of totality—eight photographs in all with the one instrument. The times of exposure varied from one second up to one hundred and fifty seconds. The difficulty of handling such large plates was overcome by a very simple device. The problem was to stop in the midst of a series of exposures, bring into po-

sition, expose and remove a heavy plate forty inches square and then go ahead with the other exposures all with the least possible loss of time. The big plate was to be exposed during the middle of totality.

This was accomplished by suspending a light wooden frame that would carry a 40x40 and a 30x30 plate holder—the 30x30 being the lower of the two—between two vertical 8 *x* 8 posts by heavy cords running over pullies on the top of the posts and suitably counterpoised with bags of sand at the other ends. With the plate holders in position this could be lowered and raised rapidly and with ease, like a window sash. The five 14 x 17 plates were in 30 x 30 plate holders for convenience. The plate holders to be used were placed in a rack to the right, perpendicular to the movable plate holder, where they could be instantly taken up and placed in position, while the exposed plate holder was lifted from the frame and leaned against the wall on a table to the left, the operator not having to move from his position on the floor during the entire work of exposing. This method is a safer and better one than the sliding plate holder used at Wadesboro.

The large plate holder was put in position once for all in its frame. At the beginning of totality a 30 x 30 holder was in position for the image to fall centrally on it. The exposure was made, the plate holder lifted aside, another substituted and exposed and when the time came for the large one the frame was pulled down to a stop, the exposure made and the large plate holder pushed up instantly and the exposures of the other plates proceeded with.

The construction of the plate holders was specially admirable for the purpose. The covering slide was made up of a great number of narrow strips of wood on a cloth surface which was pulled open from behind and ran in grooves at the edge of the plate holder both at the back and the front. The plate could therefore be uncovered by a person standing at the back of the plate holder by pulling down on the flexible slide. These, except the 40 x 40 were loaned by Professor Langley, and were the same used by Mr. Smiley at Wadesboro in 1900. The 40 x 40 was made specially for Sumatra.

The Coelostat House.

The actual exposing of the plate to the image was accomplished by a wooden slide running freely in a wooden horizontal frame supported on posts close to the object glass, between it and the mirror; this slide had a 7-inch hole in one end. At each end was

attached a strong cord. These cords ran back along the tube through screw eyes to the dark room and were carried down through the roof and hung, with weights on them, just above the observer's head and within instant reach of his hands. By pulling the left hand cord the slide was instantly shot forwards and the 7-inch hole brought over the object glass exposing the lens; at the close of the exposure this was instantly shot back with the right hand cord and the exposure closed. This exposing shutter and the lens were all built in to the end of the tube with heavy dark cloth, so that no light could enter except through the lens when the shutter was drawn aside. With this arrangement an exposure of a very small fraction of a second could be successfully given.

The two posts, between which the plate holders worked, were placed in a room ten feet square and firmly imbedded to a depth of five feet in the ground. This room was separated into two parts, in the plane of these posts, by backing up with heavy dark cloth. The first or forward compartment in which the tube opened, was occupied by the plate side of the plate holder, while the rear portion was occupied by the observer who, standing at the rear of the plate holder could by pulling down the flexible slide instantly uncover the plate, and by pulling on the two cords in reach over head could expose the plate by uncovering and covering the lens some 60 feet away.

To the left, between the post and the wall was a heavy curtain which could be pushed aside and the observer could step in to the front compartment and watch the plate during exposure. As a further convenience a mirror (borrowed from the native hotel) was placed at the proper angle in the further left hand corner of the front appartment, so that by pulling the curtain slightly aside from behind, the entire plate could be seen in the mirror. In this way at any moment, the plate could be watched by the observer from his position at the rear of the plate holder. The rear compartment could be strongly illuminated with several red lanterns so that the observer could see plainly what he was doing without in anyway endangering the plate.

The coelostat tube was horizontal and rested on supports several feet above the ground. It had been made of 8 feet 4 x 1 inch strips of wood joined to square frames of the same size strips, all of which had been put together at the Yerkes Observatory and each piece numbered, and then taken apart and crated for shipment. These were quickly put together in Solok and covered with dark red water proof paper. This tube was square

and tapered toward the coelostat, being about 40 inches square at the larger end where it opened into the dark room.

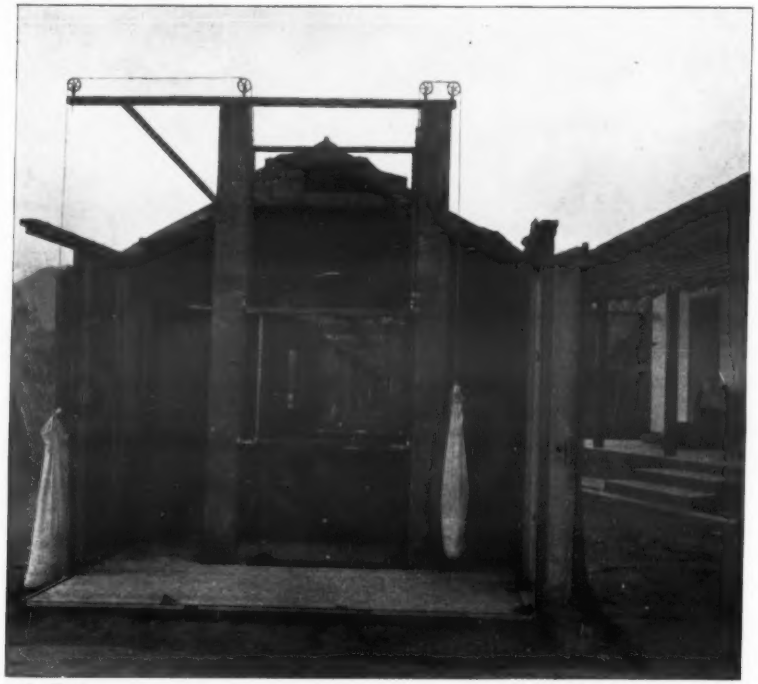
Over the top of the coelostat dark room a native roof of cocoanut leaves and bamboo, had been built to keep off the direct heat of the Sun. A series of tents had been stretched above the coelostat tube to protect it also from the heat. This protection served admirably in keeping the tube cool and in preventing air currents in it. A section of this tenting also covered the coelostat and could be shoved back to expose the mirror. This was a necessary protection, for it was found at Wadesboro in the eclipse of May 1900 that if the mirror was exposed to the direct Sun for any time it would change the focus of the lens some six or eight inches.

A door opened outside the dark room from the back compartment and a heavy curtain blocked out all light when the door was open. During totality the observer could open this door and go outside to view the eclipse while the longer exposures were going on, without danger to the plate. On the wall of the rear compartment a telegraph sounder ticked off seconds from a chronometer and thus the plates could be accurately timed.

It was the intention to shade the image during one of the long exposures. Three shaders of different dimensions on slender wire handles, were conveniently placed in the forward compartment near the plate so that they could be instantly taken up and the brighter parts of the corona shaded by a proper movement of the shader. These shaders were of different sizes and were made of thin cardboard, the edges of which were covered with finely teased cotton, which produced a soft diffusion of the edges. This by a dexterous movement in front of the plate could be made to properly lessen the action of the light at any point without other wise showing the effects of the shading. The advantage of this method is that you have the exposing plate in full view and can therefore intelligently shade any portion of the corona and grade the light of any form of corona to prevent too great over exposure of the bright inner part. Experiences at Wadesboro in the eclipse of May 1900 had shown just how much shading could be successfully accomplished. A similar shader was then used but for only a few seconds because of the apparent faintness of the image. A longer use would have materially helped the resulting negative.

The Program.

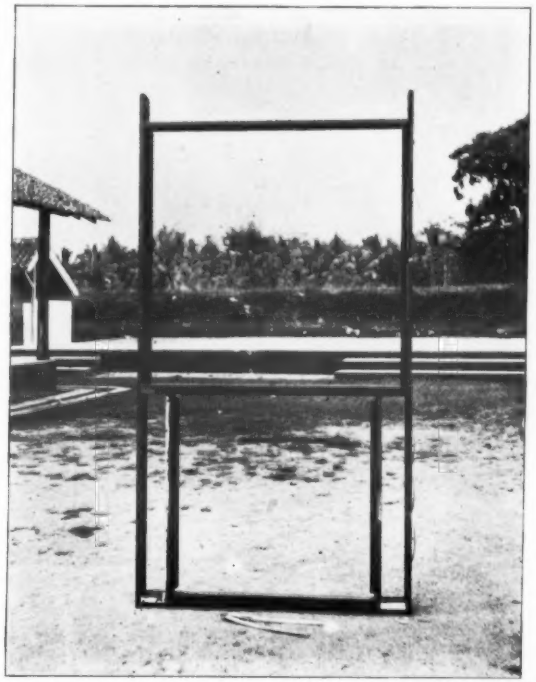
The following exposure scheme was adopted for the plates of the coelostat:



From the East. W. W. Dinwiddie, Photographer.

THE COELOSTAT HOUSE, SHOWING THE CARRIER FOR LARGE PLATE HOLDERS IN POSITION, THE METHOD OF COUNTERPOISING, ETC.

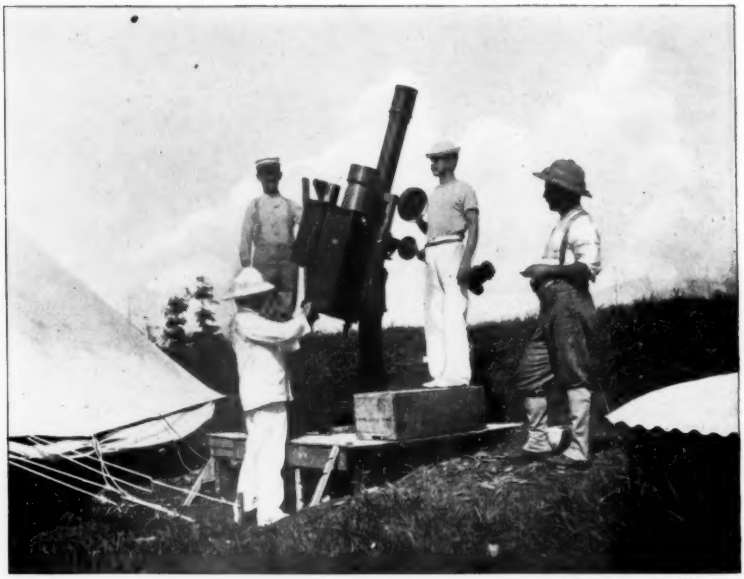
The interior of the tube is also shown.



E. E. Barnard, Photographer.

THE CARRIER FOR THE LARGE PLATE HOLDERS.

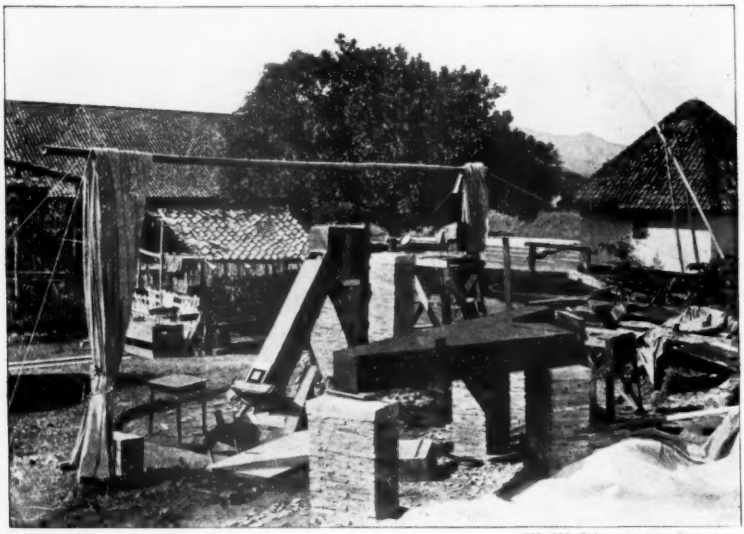
The upper space was occupied by the 40x40 holder and the lower by the 30x30 holders.



E. E. Barnard, Photographer.

THE TWO SHORT FOCUS CAMERAS MOUNTED ON 6-INCH EQUATORIAL.

Mr. Irving. Two Marines. Mr. Curtis.



From the Southwest. W. W. Dinwiddie, Photographer.

GENERAL VIEW OF THE INTERIOR OF THE FORT—
SHOWING THE SPECTROSCOPES.

The Coelostat was to the left of the large tree. The building to the right was converted into a dark room. The well sweep near this house is suggestive of New England. The large tree bore a large fruit called the "Nunka."

No.	Exposure.	Size of plate.	Kind of plate.
	s		
1	1	14 x 17 in.	Cramer crown
2	4	14 x 17 in	" "
3	16	14 x 17 in.	" "
4	30	30 x 30 in.	" "
5	150	40 x 40 in.	" "
6	60	30 x 30 in.	" "
7	8	14 x 17 in.	" "
8	1	14 x 17 in.	" "
9	½ after totality	14 x 17 in.	" "

Three 14 x 17 plates were ready in holders to be given quick exposures immediately upon the reappearance of the Sun to see how long the corona and prominences could be photographed after totality with such an instrument. One of these, No. 9, alone was used on account of the clouds.

In the careful drill that I went through in handling these large plates for a week before the eclipse, the above program from 1 to 8 was easily carried out in from $5^m\ 30^s$ to $5^m\ 35^s$. As the predicted duration of totality at Solok was $5^m\ 52^s$ this left ample margin for safety.

All the plates were thoroughly backed with a thick paint of burnt sienna and caramels. The large plates were put in their holders and their backs heavily coated with this mixture and then further backed with soft newspaper to prevent injury to the backing.

Totality.

A thorough drill had made the manipulation of these big plates easy and certain. Every precaution had been taken that no hitch should occur during totality. It was also found that no assistant whatever was needed in making these large photographs, for one man could handle them as easily as two or more.

The day of the eclipse dawned unpromising, the sky was more or less covered with clouds. Some promise of clearing away occurred in the forenoon but as the time for the eclipse drew near this changed for the worse and all hope of a clear sky was lost. By noon the sky was covered with thickish mackerel clouds through which the Sun shone feebly. As totality neared it was evident that all our efforts would prove vain. Nevertheless it was deemed necessary to go through the program in hopes of getting some traces of the corona through the clouds. At the signal for totality each observer carried out his part as if the sky were perfectly clear. During the longer exposures the plates were carefully examined but no trace of an image could be seen. It

was therefore evident that no impression could be obtained. I also went outside the dark room into the open air to examine the progress of the eclipse. The Moon could be faintly seen part of the time, through the clouds in relief against a feeble coronal ring. Venus and Mercury were plainly visible some distance to the east through a thin place in the clouds. The corona was examined with a small telescope prepared specially for the purpose, but nothing could be made out of it on account of the clouds.

During totality one was struck with the great amount of illumination. To me the light was similar to that of a heavily over cast day, in which it would have been easy to read ordinary newspaper print without artificial illumination. This in part was doubtless due to the fact that I had been shut up in the dark room for a short time before totality and that my eyes had in consequence become very sensitive. Perhaps, also, this general brightness was partly due in some way to the clouds which scattered and diffused the sunlight from outside the shadow.

But the eclipse was over, and the best preparations ever made for the observations of a total eclipse of the Sun had come to naught. It was with no light heart that the plates were developed. The small, quick acting lenses which were under the charge of Mr. H. D. Curtis and which were exposed by Mr. G. E. Irving and two marines, had secured at most the image of the Moon with a thin ring of light about it and the clouds themselves in the region of the eclipsed Sun. One of the long exposures, indeed, though it showed the clouds well, did not show any trace of the eclipse. The large plates showed feeble fragments of the chromospheric ring with a few prominences.

The development of the large plates was easily done. Wooden trays of the proper size had been brought along and were heavily paraffined before using. In developing the 40 x 40, which was a heavy plate glass, the help of Mr. Curtis made the handling of it a very simple affair. The two 30 x 30 plates and the six 14 x 17 plates were developed without any aid.

The most exasperating part of it all was, perhaps, the fact that if instead of going away off into the interior to search for good weather, we had simply gone ashore from the gunboat that carried us to Sumatra and put up our instruments on the sea shore or near it, we should have had successful observations, for the ships people had a fine view of the eclipse with nearly twenty seconds longer duration of totality. But this was something that could not be foreseen for the meteorological reports had made Solok the most favorable of all the stations.

Effect of the Eclipse on the Natives.

Considerable uncertainty had existed as to what effect the total disappearance of the Sun at mid-day might have on the Malays. All sorts of speculations had been put forth as to what might result. Had there been any apprehension, however, on the part of the observers they would have felt reasonably safe inclosed as they were in a strong fort. Had any thought of danger suggested itself in the early preparations from this source it gradually wore away as the friendly attitude of the natives became more and more apparent. They showed no more than the ordinary interest and no excitement was evident, though a great Mahometan festival and procession occurred a short time before the eclipse. For a few afternoons preceding the 18th the natives would congregate along the side of the road, which curved around the fort in a semi-circle a few hundred yards away, squatting here and there along the roadside silent and motionless for hours at a time, watching the fort and what little preparations could be seen over the ramparts. It is wonderful how long a Malay can squat on his heels without any apparent motion. In such a position the legs of the ordinary white man would become numb with pain in ten minutes time, but the Malay can keep it up for hours without apparent discomfort.

On the day of the eclipse great numbers of the native men lined the road side and silently looked in our direction. Whether they watched the fort during totality or the eclipsed Sun I do not know, but I heard no noise from any of them. When the eclipse was over they quietly returned to their homes. On leaving the fort a short time later I passed one of the prisoners, who had helped to move our freight from the station, quietly cutting grass in front of the fort. He smiled sadly and pointing to the fast reappearing Sun quietly uttered one word, "sudah," which can be translated, "it is finished." Passing through a group of natives returning to the town, they expressed an interest as to the result and when informed that we had not been successful some of them expressed much sympathy in their looks.

One of the most unpromising places in Sumatra according to the meteorological reports was Padang-Panjang. It rained there all the time and there was certainly no chance for observations at that point, so astronomers passed it by though it was more convenient than any of the other stations in the interior. There was a story told of a Dutchman who lived at Padang-Panjang, who was very anxious to see the eclipse, but he had no faith in

Padang-Panjang and so he came down to Solok to get a view of the corona. As chance would have it, it was splendidly clear during totality at Padang-Panjang.

SUMMATION.

Though the most important preparations for observing the eclipse failed from clouds, very satisfactory results were obtained at some points fully justifying the outlay of time and energy in going so far to observe the phenomenon.

Even at Solok some spectroscopic results were obtained at first contact.

One of the most interesting things in the photographs of this eclipse is a remarkable region of local disturbance shown in the corona as if some unusual action were taking place at that point. In previous eclipses all the details of coronal structure have apparently had their origin in the Sun and hence the present phenomenon is of very great interest and importance as it may tend to throw some light upon the nature of the corona. So far as the physical features of the corona are concerned this was the most important part of the eclipse.

It has been shown that the form of the corona is in some way dependent on the condition of activity of the Sun. A quiescent condition, shown by the absence of sunspots, seems to produce a corona with great wing-like extensions in the equatorial regions, and magnificent polar fans made up of streams of radiating light strongly like the mysterious rays of the northern lights and hence vaguely suggesting a possible similarity of origin. When sunspots are most frequent the corona is more symmetrical in its arrangement about the Sun and has been called the "Sun flower form."

At the time of the present eclipse the Sun was still in a quiescent state and the corona bore the characteristic form peculiar to such conditions, similar to the coronas of 1889-1900. The prominences or Sun flames were unusually small.

So far as this eclipse is concerned, and everything rested on it, the intra-Mercurial planet question is in the same condition that it was before the eclipse. It should have been pretty generally settled, if all the stations had had clear weather, for there were at least four outfits specially designed to search for any planet that might exist nearer the Sun than Mercury. The Smithsonian Institution represented by Mr. Abbott; the Lick Observatory by Mr. Perrine; the Boston Technological Institute represented by Professor Burton, and the large Dutch party were all supplied

E. E. Barnard, Photographer.

THE VALLEY IN WHICH LIES SOLOK, FROM THE EAST.

The lighter and darker regions in the valley are rice fields and cocoanut groves. Solok lies in the grove on this edge of the brighter strip at the foot of the hills in the distance. The bright region is not water, but rice fields, made bright by the engraver by mistake.

E. E. Barnard, Photographer.

NEAR SOLOK.

Native house and rice barn—the rice barn is the small building in front. The trees are cocoanut palms and banana trees. The foreground is a rice field.

with powerful photographic instruments capable of showing any object near the Sun during totality as faint as the 7th or 8th magnitude. Clouds so interferred in each case, however, that the question of the existence or non-existence of such objects must remain for future eclipses to settle.

I understand, later, that the clouds did not interfere so badly with Professor Perrine and that he secured impressions of stars nearly as faint as the 9th magnitude.

If the eclipse had happened two weeks earlier a great comet would have been caught on the photographs near the Sun, as occurred at the eclipse of May 1882 in Egypt when the blotting out of the Sun revealed a fine comet quite close to it.

On the evening of May 3rd a brilliant comet suddenly made its appearance just after sunset close to the horizon. It presented a fine appearance to the naked eye for a few minutes before it set. It was rapidly leaving the Sun and was seen on several subsequent evenings when photographs were secured of it. Clouds, however, made it impossible to get a series of photographs while it was bright. Though this comet had been seen a month earlier farther south, it was first seen at Solok on the above date by Mr. Dinwiddie of the Naval Observatory party.

Though the main part of the expedition was unsuccessful on account of clouds, it is a great satisfaction to know that a portion of the expedition—that located at Fort de Kock—was favored with a clear sky, and that excellent results were secured at that point.

Terrestrial Rain Clouds vs. Celestial Star Clouds.

It was my intention to make a series of photographs of the southern part of the Milky Way during the stay at Solok and the two portrait lenses had been carried along mainly for this purpose as was also a very short focus lens of 4 inches aperture. It was found absolutely impossible to do this work because of the constant cloudiness of the sky. Only one night proved entirely clear in the absence of moonlight during all the time, and this, as if in mockery, was the night of the 18th of May. It was beautifully clear up till midnight and from that on was more or less covered with wet haze. Two exposures were obtained during this clear spell. Though the stars were seen on a number of nights, it was always between breaks in the clouds. This same cloudy condition held also in the day time, so that the sky was essentially never free of clouds.

The Sun was examined a number of times with the 6-inch, and

the seeing was found in general to be excellent, while at night it was unsteady.

The night before leaving for Manila, while at the Oranje Hotel in Padang, we had the pleasure of meeting a number of the members of the other expeditions including Mr. Perrine of the Lick Observatory, Mr. and Mrs. Newall, and Mr. Dyson, of the English parties.

The United States Consul.

To Mr. C. G. Veth, the United States Consul, at Padang we were indebted for the greatest kindness shown in many ways and regardless of expense. He did everything to help us that lay in his power.

One Consolation!

To console us for our lack of success and to cheer our sad spirits, a big ball was given to us at Padang the night before we left Sumatra. This was highly appreciated by the younger officers of the gunboat.

The Return.

On the return the General Alava left Emmahaven on the morning of May 28 at half past ten. We passed again through the Strait of Sunda and at 3:00 p. m. on May 30, were within half a mile of the south side of Krakatoa. The interest in this remarkable place was in nowise diminished by a second visit. There have been no signs of activity since the memorable catastrophe that wrecked the island.

On the way back the vessel stopped a day at Batavia, in Java, for coal and finally reached Manila on the morning of June 8th, at half past ten. We sailed from Manila direct to San Francisco at midnight of June 20th on the transport Indiana, Captain Morley, and arrived at San Francisco in the forenoon of July 16th.

The officers of the various vessels on which we sailed showed us every courtesy and attention.

To Professor Skinner I am indebted for every possible courtesy. Everything in his power was done to make the expedition a success.

The illustrations accompanying the above article are only a very few of the hundreds obtained by Professor Barnard while on his trip to Sumatra. Those of the Krakatoa island will interest all lovers of astronomy.

THE LIGHT CURVE OF THE NEW STAR IN PERSEUS.

CONTINUED FROM PAGE 487.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
6		Solá		3.2	2.9	
	8.5	Wickham	17 comparison stars	3.03	3.02	R
	9.8	McClellan		3.01	2.91	
	11.3	Luizet		3.3		
	12	Seagrave	N 1 γ		3.0	
	12	Olivier	$0.05^m > \epsilon$		2.88	
	12.5	Micou	ϵ ½ N ½ δ	3.02	3.05	
	12.5	Hagen	ϵ 3 N 3 δ		3.02	
	13.0	Whitney	N 2 δ; N 1 γ	2.9	2.94	
	13.0	Yendell	δ 2 N	3.38	3.30	O
	13	Young	N 1 δ	3.0	3.0	
	13.2	Sperra	ι Aurigæ 4-5 N 1-2 ϵ		2.92	
		Upton		3.2		
	13.3	Comstock	δ 2 N 4 ν	3.35	3.42	
	13.5	Wendell	Photometer	3.05		
	13.5	Parkhurst	Photometer	3.08		
	14	Seagrave	γ ½ N ½ δ		3.1	
	14	Olivier	$= \epsilon$		2.93	
	14	Wilson	$\gamma = \epsilon > N > \delta$		3.05	
	14.0	Jones		3.05		R
	14.4	Daniel		2.92		
	15	Seagrave	γ ½ N ½ δ		3.1	
	15.3	Olivier	$0.05 > \epsilon$		2.88	
	15.5	Hadden	$= \delta$	3.1	3.10	
7	3.3	Stratanow	N 4 ϵ; N 3 γ; β 5 N; δ Cass. 1 N	2.84	2.82	
	5.7	Ambronn		3.51		
	6.5	Küstner	β 5 N 3 δ; N 1 γ; N 2 ϵ		2.85	
	6.6	Nijland		3.21		
	6.7	Müller A.	β, ϵ	3.0		R
	6.9	Plassmann	ϵ 1 N 3 δ		2.97	
	7.0	Honnorat		3.4		
	7.6	Plassmann	ϵ 3 N 3 δ		3.02	
	7.7	Riccò	$> \nu$ and a little $< \epsilon$		3.3	
		Solá		3.2	2.9	
	8.4	Plassmann	ϵ 3 N 2.5 δ		3.05	
	8.7	Winkler	δ ϵ ν	3.3		Y*
	8.9	Plassmann	ϵ 2 N 4 δ		2.99	
	9.3	Luizet		3.2		
	9.5	Epstein	$\beta > N > \epsilon$			
	11	Fauth	Almost $= \delta$, $< \epsilon$	3.05	3.05	
	11.3	Messow	$\epsilon > N > \nu$; through clouds			
	11.8	Wickham		2.75	2.65	†
	11.9	Robinson		2.78	2.71	VR
	12.0	Bellamy	$=\gamma$ and δ	3.14	3.04	‡
	12.0	Yendell	N ($\beta - \delta$)	2.75	2.75	
	12.0	Seagrave	ζ 1 N 1 γ		3.00	
		Upton		3.0		
	12.3	Hagen	N 0 ϵ		2.93	
	12.5	Micou	Unchanged	2.95	3.05	
	12.7	Olivier	$0.10^m > \epsilon$		2.83	
	13.0	Young	N 1 γ	2.9	3.0	
	13.0	Sperra	ι Aurigæ 5 N 4 ϵ		2.92	
	13	Seagrave	ζ 1 N ½ γ		3.02	

* Dark yellow; somewhat reddish. † Not nearly so red. ‡ Less orange.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar	h					
7	13.3	Olivier	$0.15^m > \epsilon$		2.78	
	13.4	Zwack	N 3 ϵ		2.83	
	13.4	Daniel		2.92		
	14	Seagrave	ζ 1 N 1 γ		3.00	
	14	Olivier	$0.20^m > \epsilon$		2.73	
	14.0	Parkhurst		3.2		
8	5.9	Laska	ϵ 1 N = γ		3.10	
	6.3	Epstein	N > ϵ			
	6.5	Harkányi	Photometer	3.49	3.26	R
	6.5	Luizet		3.3		
	7	Pidoux	δ, ϵ			R*
	7	Fauth	= δ; < ϵ	3.1	3.1	Y†
	7	Deichmüller	N 1-2 γ			
	7.0	Honnorat		3.4		
	8	Schwab	N = or > γ	3.0		
	8.0	Luizet		3.0		
	8.5	Robinson	ϵ, δ	3.10	3.00	VR
	8.8	Pola	2 observers	2.9		R
	8.9	Laska	ζ 2 N; γ 1 N; N 1 δ		3.1	
		Oertel	ν	4.0		
	8.9	Luizet		3.0		
	9.9	Jost	Photometer	3.75		
	10	Gautier		3.2		
	11.0	Epstein	= ϵ		3.1	
	13.5	Olivier	0.1 > δ; 0.2 > ϵ	3.2±	2.85	‡
9	6.5	Müller A.	ϵ, δ	3.1		¶
	6.6	Laska	6 3 δ, δ 2 N		3.18	
	8.0	Harkányi	Photometer	3.67	3.44	R
	8.9	Robinson	ϵ, δ, κ, ν	3.62	3.57	
	9	Köhl		4.79		DR
	9.1	Wickham	γ, δ, η, ν	3.57	3.52	
	9.4	Rambaut	ϵ, γ, ζ, ρ, κ, ν, o, ξ, ι, θ	3.65	3.61	
		Solá		3.8	3.5	
	10.0	Williams	δ 2 N 5 ϵ; γ 1 N	3.3	3.02	
		Sharp		3.4?		PO
	10.5	McClellan	ϵ, γ, δ, κ, ν	3.56	3.51	
	12.2	Zwack	β 14 ϵ 6 δ 5 N 2 γ		3.14	
	12.5	Hagen	δ 5 N 2 γ		3.08	
	13.5	Micou	N 3 ν	3.5	3.63	
	14	Wilson	ϵ > N > ν	3.5±		
	15	Olivier	0.2 > δ ; 0.3 > ϵ		2.75	
10	4.6	Sviatsky		3.7		
	7.6	Sviatsky		4.1		
	8	Schwab	γ > N = or > δ		3.1	RY
	8.2	Harkányi	Photometer	3.49	3.26	R
	8.1	Wickham	γ	3.10	3.07	
	8.6	Graff	γ, δ	3.35	3.19	
	9	Schorr	N = δ		3.10	DR
		Solá		3.5	3.2	
	9.0	Robinson	κ, ν	3.70	3.69	
		Oertel	ϵ	3.5		
	10.0	McClellan	κ, ν, ϵ, δ	3.68	3.63	
		Sharp		3.3		PO
	14.0	Hadden		3.1		
11	6.9	Laska	ϵ 3 N; γ 2 N; δ 1 $\dot{N}$		3.2	

* R; nearer purple than orange. † Y; slight tinge of carmine red. ‡ Through heavy smoke. ¶ Color of Aldebaran.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
11	7.0	Müller A.	δ	3.1		RY
	7.1	Raynaud		$<$3.0		
	7.2	Honnorat		4.0		
	8	Anckermann		3.2		R
		Solá		3.5	3.2	
	8.8	Pola	4 observers	3.3		R
		Sharp		3.6?		
	10.8	Robinson	ν, κ	3.93	3.92	
	12.4	Bohlin		3.6		
	12.5	Olivier	$0.3 < \delta$; $= \rho$; $0.5 > \nu$; $0.6 > \kappa$; $0.2 < \gamma$		3.44	
	13	Micou	N 3 ν		3.63	
	13.5	Parkhurst	Photometer	3.62		
	13.7	Comstock	N κ	4.1	4.00	
	14	Seagrave	N ½ ρ		(3.7)	
	14	Wilson	α 5 β 10 ϵ 2 γ 1 δ 5 η = N 1 κ 1 ν 1 ι 1 θ 1 σ 1 ψ 3 l		3.81	
	15	Brenke	δ 4 N 3 ν	3.5	3.57	
12	5.9	Laska	δ 3 N		3.4	
	7.0	Pola	4 observers	3.45		
	7.6	Raynaud		$<$3.0		
	8.0	Harkányi	Photometer	3.29	3.06	R
	8.3	Riccò	N $> \nu$; $= \epsilon$	3.16	2.93	
	9.3	Bohlin		3.4		
	10	Soares		3.0		
	10.5	Williams	δ 2 N = γ	3.25	3.13	W*
	10.8	Robinson		3.87	3.78	
	11.0	Gyllensköld	δ, γ	3.22		
	11	Graff	δ, ϵ, ν	3.4	3.2	
	12	Seagrave	δ 1 N 1 ρ		3.3	
	12.2	Yendell	δ 2 N	3.38	3.30	
	12.5	Daniel		2.96		
	13	Young	N = δ	3.1	3.10	
	13	Seagrave	δ 1 N ½ ρ		3.3	
	13	Micou	δ 2 N 6 ν		3.32	
	13.5	Parkhurst	Photometer	3.30		
	14	Olivier	$0.2 < \delta$		3.3	
	15	Seagrave	δ 1 N 1 ½ ρ		3.3	
	15.0	Jones		3.31		
	16.5	Whitney	δ 2 N 4 ν	3.4	3.38	
13	5.1	Sviatsky		4.0		
	6.0	Gyllensköld	δ, μ, ν, l Persei; ϵ, ζ, η Aurigæ	3.77		
	6.5	Köhl	$< \epsilon$, $> \nu$		3.4±	
	7.0	Plassmann	δ 7 N 1 ν; N 4 κ		3.74	
	7.0	Müller A.	δ, ϵ, ν	3.5		
	7	Fauth	N 1 ν 1 κ	3.9	3.9	Y†
	7.5	Graff	δ, ν	3.7		
		Glasenapp		3.6		
	7.8	Robinson	κ, ν, ι	4.03	4.04	
	8	Ventosa	$< \delta > \nu$	3.7		R
	8.5	Riccò	Photometer: α, δ	4.07	3.82	
	8.6	Plassmann	δ 7 N 4 ν; N 5.5 κ		3.60	
	9	Anckermann		3.5		YR
	9.0	Plassmann	δ 7 N = ν; N 4 κ		3.75	
	9.0	Jost	Photometer; clouds near	4.18		
	9.3	Bohlin		3.4		

* Perhaps slight reddish tinge. † Yellow with tinge of red.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
13	9.5	Ambronn	Scarcely brighter than ν	3.95	3.9	
		Solá		4.2	3.8	
	9.8	Plassmann	δ 7 N = ν; N 4 κ		3.75	
	10	Soares		3.58		
	11.0	Gyllensköld	ν Persei; ϵ, ζ Aurigæ	3.61		
	11	Epstein	$\nu > N > \kappa$		4.0	
	12.5	Hagen	γ 5 ζ 3 N 2 κ		3.61	
	13.3	Zwack	γ 4 ζ 9 N 7 κ		3.58	
	13-15	Olivier	$0.2 > \nu$		3.7	
	14	Micou	N 2 ν	3.7	3.73	BR
14	3.5	Stratanow	δ 2.5 N; ζ 4 N 4 η; N 3 ϵ Cass.	3.34	3.35	
	7.0	Müller A.	δ, ϵ, ν	3.6		
	7.5	Harkányi	Photometer	3.75	3.52	R
	8	Ventosa	$< \delta$, = or $> \nu$	4.0	3.9	R
	8	Deichmüller	N 3 ν			
	8	Pola	3 observers	3.43		
		Glasenapp		3.7	3.6	
	8	Epstein	$N > \nu > \kappa$			
	8.1	Raynaud		< 3.0		
	8.5	Riccò	$N > \nu$; $< \delta$; difference equal	3.68	3.52	
		Oertel	ϵ	3.5		
	8.5	Küstner	δ 3 N 3 ν	2	3.52	
	9.8	Riccò	Photometer; α, δ	3.84	3.59	
	10.1	Jost	Photometer	3.57		
	12.2	Hagen	ζ 5 N 5 ν 3 κ		3.37	
	13	Micou	δ 3 N 5 ν	3.35	3.42	
	13-15	Olivier	$0.2 < \delta$		3.3	
	13.3	Zwack	γ 4 ζ 8 N 10 ν 3 κ		3.45	
	13.5	Parkhurst		3.5		
	14.4	Wendell	Photometer	3.30		
15	5.6	Laska	N 1-2 η; N 3 ν		3,7	R
	6	Graff	δ, ν	3.4	3.2	
	6.0	Gyllensköld	δ, ν	3.33		
	6.5	Gyllensköld	δ, ν	3.53		
	6.5	Messow				YR*
	6.8	Schorr	δ 2 N; ϵ 4 N		3.3	
	6 7	Nijland	With naked eye	3.34		
	6.7	Nijland	With opera-glass	3.26		
	7.0	Müller A.	δ, ϵ, ν	3.7		
	7.0	Riccò	N = ν and κ	4.01	3.96	
	7.6	Sviatsky		3.9		LR
		Glasenapp		3.7		
		Solá		3.8	3.5	
	9	Fauth	N 2 ν 1 κ		3.8	
	9.0	Riccò	Photometer : ϵ, 775 PPD	4.14	3.91	
	9.1	Archenhold	N 2 ν 3 κ	4.05	3.8	
	9.5	Soares		3.54		
	9.7	Schorr	N 2 κ; N 1 ν		3.8	
	11.0	Jost	Photometer	3.62		
	12.0	Zwack	ζ 11 N 6 ν		3.57	
	12.5	Hagen	ζ 6 N 4 ν		3.52	
	13.0	Comstock	κ = N = ν	4.0	3.96	
	13.5	Parkhurst	Photometer	3.72		
	14	Brenke	N 2 ν	3.7	3.7	
	14	Wilson	α 10 β 10 γ 2 ϵ 2 δ 3 η = N 1 κ 1 ν 1 τ 1 ι 1 θ 1 σ 1 ψ		3.71	

* α Tauri far yellower.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
15	14.7	Comstock	$\nu\kappa$ 1 N	4.1	4.06	
	16.2	Hadden	Same as ν	3.9	3.9	
16	5.0	Stratanow	η 4 N; ϵ Cass. 5 N 2 c; N 3 ν; N 5 κ	3.88	3.85	
	6.0	Laska	κ 3 N; ν 2 N		4.2	
	6.1	Nijland		3.85		
	6.6	Graff	κ, ν	4.05	3.99	
	7.0	Müller A.	ν	3.9		
	7.3	Honnorat		4.3		
		Glasenapp		3.8		
	7.7	Riccò	Photometer: δ, 725 PPD	4.06	3.84	
	8	Anckermann		3.9		CR
	8.5	Robinson	δ, κ, ν, ι, θ	3.98	3.96	
		Sharp		3.8?		
	8.5	Pola	2 observers	4.05		
	9.0	Wickham	γ, η, κ, ν	3.63	3.62	
	9.0	Harkányi	Photometer	4.18	3.95	
	9.3	Luizet		3.7		
	10.0	Fauth	N = ν 1 κ		3.9	
	12.2	Daniel		3.60		
	12.5	Hagen	ζ 10 1 N 3 ν		3.69	
	12.5	Furness	κ 2 N 2 ι; ν 1 N	4.1	4.05	
	13	Young	ν = N = κ	4.0	3.96	
	13	Micou	ν 1 N 2 ψ	4.0	4.04	
	13-15	Olivier	0.1 < ν		4.0	
	13.5	Zwack	ζ 13 N 4 ν		3.69	
	13.8	Furness	κ 1 N; ν 2 N 1 ι	4.1	4.09	
	14	Wilson	κ ½ N ½ ν		3.96	
		Comstock	N 2 ($\nu\kappa$)	3.8	3.76	
	14.5	Jones		3.72		
	14.5	Parkhurst	Photometer	3.69		
	14.5	Whitney	ν = N 2 κ	3.9	3.93	
	14.8	Yendell	ϵ 4 N 3 ν	3.76	3.50	
	15.6	Whitney	N 1 ν; N 2 κ	3.8	3,82	
	16.0	Wendell	Photometer	3.75		
	16.2	Hadden	Trace brighter than ν	3.7		
17	3.1	Stratanow	N 4.5 ν; N 4 κ; δ 4 N; η 2 N; ϵ Cass. 4 N	3.68	3.70	
	5.9	Laska	N 2-3 ν; N 1 = κ		3.8	
	6.5	Nijland		3.65		
	6.8	Plassmann	δ 7 N 4.5 ν; N 5.5 κ		3.61	
	7.0	Müller A.	ν	3.9		
	7.2	Laska	N 3 ν; N 1-2 κ		3.7	
	7.2	Riccò	N > κ; < ν	4.02	3.9	
	7.7	Riccò	Photometer: ϵ, 725 PPD	4 11	3.89	
	8	Pola	3 observers	3.7		
	8.5	Ambronn	= ν	4.0	3.93	
	8.5	Archenhold	N 2 ν 3 κ	4.05	3.8	
	8.6	Graff	ν	4.0	3.9	
		Solá		4.2	3.8	
	12.2	Seagrave	ρ 1 N 2 κ		3.8	
	12.3	Yendell	ϵ 5 N 2 ν	3.71	3.64	FO
	12.5	Daniel		3.45		
		Harvard		3.8		
		Comstock	N 2 ($\nu\kappa$)	3.8	3.76	
	13	Micou	N 1 ν	3.8	3.83	
	13.3	Hagen	ζ 7 N 6 ν !		3.46	
	13.3	Zwack	ζ 11 N 8 ν		3.50	

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised	
Mar.	h					
17	13.5	Parkhurst	Photometer	3.50		
	13.7	Seagrave	ρ 1 N 1 ½ κ		3.85	
	14.0	Hadden		3.7		
	14.0	Sperra	δ 5-6 N 5 ν		3.55	
	14	Brenke	N 2 ν	3.7	3.7	
	14.2	Furness	δ 3 N 2 ν; N 2 η	3 6	3.60	
	14-15	Whitney	N 2 ν; N 2 κ; N 2 η	3.7	3.75	
18	3 4	Stratanow	N 6 κ; N 3 η; N 2 ϵ Cass.; ϵ 5 N; γ 5 N; δ 3 N	3.48	3.35	
	5.1	Stratanow	N 5 μ; N 3 ϵ Triang.; δ 4 N; ζ 6 N	3.56	3.65	
	6.3	Nijland		3.76		
	6.5	Gyllensköld	ν, κ Pers., ϵ, ζ, η Aur.	3.78		
	7.7	Bohlin		3.3		
	8.0	Riccò	Photometer: ϵ	3.60	3.37	
	9.8	Williams	δ 10 N; γ 9 N; ν 2 N 2 ρ	4.13	3.80	
	10.0	Gyllensköld	ν, κ, δ	3.75		
	11.0	Robinson	ν κ	4.00	3.99	
	12.2	Whitney	N 1 ν; N 1 η	3.8	3.83	
	12.7	Daniel		3.72		
	12.9	Seagrave	ρ 1 N 1 κ		3.85	
	13	Micou	ν 1 N 2 ψ	3.95	4.04	
	13-15	Olivier	$= \nu$		3.93	
	13.0	Hagen	ζ 10 N 4 ν		3.64	
	13.0	Zwack	ζ 13 N 5 ν		3.65	
	14.4	Wendell	Photometer	3.82		
	14.8	Whitney	N $= \nu$; N 1 η	3.9	3.88	
19	3.1	Stratanow	N 2 l; σ 3 N; ξ 4.5 N; λ 4 N	4.80	4.85	
	3.4	Stratanow	N 2 l; N 1 o; ω 3 N; σ 4 N; d 3 N f 1 N	5.03	4.96	
	7	Fauth	A little $<$ than l		5.1	RY
	7	Jost		5.2		
	7	Köhl	Between clouds	5 to 6		
	7.0	Gyllensköld	ν, κ, σ	4.51		
	7.3	Glasenapp	κ 15 N; ν 13 N; l 1 N 3 (72); N 4 (83); N 7 (71)	5.27	5.00	
	7.9	Laska	l 3 N; σ 2 N; ψ 3 N		4.83	
	8	Anckermann		4.0		R
	8.3	Jost	Photometer	4.93		
	8.6	Glasenapp	l 1 N 3 (72); N 3 (71); N 5 (83)	5.25	5.12	
	9.1	Luizet		5.3		
	9.8	Gyllensköld	ν, κ, σ	4.51		
		Solá		5.4	4.9	
	10.0	Bohlin	l 1 N 4 (72)	5.2	5.10	
	11.8	Yendell	l 4 N 3 (71)	5.10	5.24	
	12.2	Seagrave		5.5		R
	13	Micou	N 1 l; N 4 (72)	5.0	4.75	
	12.6	Wendell	Photometer	5.05		
	13-15	Olivier	$>$ (71) and (72); $= l$		5.03	
	13	Young	N $= l$	5.1	5.03	
	14.0	Furness	N 1 l	5.0	4.93	
	15.2	Hagen	ν 3 κ 10 N 3 l		4.79	
	15.5	Zwack	ν 8 κ 9 N 5 l		4.68	
20	3.6	Stratanow	N $= \eta$; ϵ Cass. 3.5 N; δ 6 N 3 ν N 2 κ; N 2 c; N 4.5 ξ	3.87	3.74	
	6.2	Glasenapp	ϵ 12 N; δ 10 N 3 κ; N 2 ν; N 20 l	4.02	3.74	
	6.5	Köhl	A little $<$ ν		4.0	
	6.9	Laska	N 1-2 ν; N 3 κ		3.75	

Date 1901	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
20	7.2	Glasenapp	ϵ 13 N; δ 10 N 2 κ; N 3 ν; N 7 *l*	4.05	3.80	
	7.5	Messow	δ 5 N 2 ν; 3 N 3 κ		3.68	*
	7.6	Riccò	Photometer: ϵ	3.15		
	7.8	Bohlin		3.6		
	8	Gyllensköld	ν, κ, δ	3.44		
	8.5	Pola	2 observers	3.53		
	9.0	Robinson	κ, ν, γ, δ, θ	3.74	3.71	
	9	Anckermann		3.9		B
		Solá		4.0	3.6	
	9.0	Gyllensköld	ν, κ, δ	3.45		
	9.1	Raynaud		$<$3.0		
	9.1	Glasenapp	ϵ 5 N; δ 3 N 5 κ; N 6 ν	3.52	3.43	
	9.8	Glasenapp	ϵ 6 N; δ 3 N 2 κ; N 5 ν	3.64	3.54	
	10	Soares		3.44		
	10.5	Gyllensköld	ν, κ, δ	3.44		
	11.0	Glasenapp	ϵ 3 N; δ = N 4 κ; N 5 ν	3.45	3.28	
	12.0	Gyllensköld	ν, κ, δ	3.40		
	14	Wilson	γ 2 ϵ 2 δ 1 N 2 κ 1 ν 1 θ 1 σ 1 ψ		3.55	
	15.0	Comstock	N 3 ν; N δ	3.30	3.32	
21	4.1	Stratanow	N 5 ν; N 4 κ; N 4 *c*; η 3 N; δ 7 N; η Aur. 4.5 N	3.78	3.68	
	6.2	Gyllensköld	β, δ, ϵ	3.42		
	6.4	Gyllensköld	ν, κ	3.42		
	6.5	Messow				†
	6.5	Deichmüller	N 2 ν		3.8	
	6.8	Bohlin		3.5		
	7.0	Gyllensköld	$\nu\kappa$	4.02		
		Glasenapp		3.8		
	7.1	Plassmann	δ 7 N = ν; N 5 κ		3.73	
	7.2	Honnorat		4.3		
	7.4	Plassmann	δ 7 N 1 ν; N 4.5 κ		3.72	
	7.5	Riccò	A little < ν	$<$4.03		
	7.6	Raynaud		4.0		
	7.7	McClellan	γ, δ, κ, ν	3.65	3.62	
	7.8	Wickham	η, κ, τ, ν	4.03	4.05	
	8	Anckermann				CR
	8.3	Wickham	η, κ, τ, ν	4.03	4.05	‡
	8.5	Riccò	Photometer: ϵ, 725 PPD	4.22	4.00	
	8.6	Robinson	$\kappa\nu$	3.70	3.69	
	10	Soares		3.85		
	10.1	Bohlin		4.0		
	10.7	Jost	Photometer	3.97		
	10.8	McClellan	ϵ, γ, δ, κ, ν	3.94	3.89	
	11.0	Robinson	κ, ν, ι, θ	4.00	4.00	
		Solá		4.3	3.8	
	12.0	Gyllensköld	$\kappa\nu$	4.17		
	13.0	Whitney	N = ξ	4.1	4.05	
	13.0	Daniel		4.33		
	13.0	Furness	ι 1 N 2 *l*	4.5	4.46	
	13	Young	N = σ	4.5	4.55	
	13	Micou	*l* 1 N 2 (72)	5.2	5.15	R
	14	Wilson	α 7 β 7 γ 1 ϵ 2 δ 3 ρ 2 η 1 κ = ν 1 θ = ι 1 τ 1 σ 1 ω 1 N 1 ψ 5 *l*		4.51	
	14.2	Stebbins	N = *l*		5.03	
	14.5	Furness	ι 3 N 1 *l*	4.8	4.82	

* Not so red as on the 15th. † Not so red as before; more yellowish. ‡ Red with more yellow than when last seen. ν is bluish white.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h					
21	15	Wilson	$\alpha 7 \beta 7 \gamma 1 \epsilon 2 \delta 2 \rho 2 \eta 1 \nu 1 \kappa 2 \theta 1 \iota$ 1 τ 1 σ 2 ω 1 N 1 ψ 3 *l*		4.51	
	15.2	Hagen	ν 3 κ 7 N 10 *l*!		4.45	
	15.2	Comstock	κ 5 N 2 σ; N 2 *l*	4.63	4.59	
	15.3	Zwack	ν 5 κ 10 N 8 *l*		4.60	
	15.5	Bohlin		4.2		
	15.5	Hadden	N = ι	4.2	4.18	
	16.0	Whitney	ψ 1 N 2 *l*; ψ N (71)	4.6	4.76	
22	6.1	Nijland		5.10		
	7	Köhl		5		DR
	7	Gyllensköld	*l*, (71)	5.07		
	7.5	Honnorat		5.5		
	7.8	Robinson	*l*	5.20	5.39	
	8	Anckermann		4.3		CR
	8.0	Riccò	Much < ν	< 4.03		
		Glasenapp		5.4		
	8.1	Raynaud		5.0		
	8.4	Bohlin		5.2		
	8.9	Riccò	Photometer: ϵ, 725 PPD	5.64	5.42	*
	9.0	Gyllensköld	*l*, (71)	5.07		
	9.5	Epstein	N = *l*		5.03	
	10	Gyllensköld	*l*, (71)	5.07		
	10.2	Williams	*l* 5 N 3 (71)	5.22	5.23	R
		Solá		5.7	5.2	
	12.7	Hagen	κ 2 ξ 5 N 12 *l*		4.36	
	12.9	Zwack	κ 8 ξ 3 N 8 *l*?		4.45	
	13.0	Micou	N 1 ω; N 3 *l*	4.8	4.74	
	13	Young	N = σ	4.5	4.55	
	13	Sperra	Very much < ν			
	13.2	Comstock	N 1 σ; N 3 *l*	4.55	4.59	
	13.2	Jones		4.70		
	13.5	Stebbins	N σ; N (κ*l*)	4.55	4.54	
	13.5	Wilson	κ = ν 2 N = ι		4.18	
	13.5	Whitney	ν N *l*	4.5	4.48	
	14.2	Parkhurst	Photometer	4.08		
	14.8	Whitney	N = τ; N 1 ψ	4.1	4.11	
	14.9	Daniel		4.55		
	15.0	Stebbins	(κ 1 N 2 σ); N 1 ι	4.17	4.25	
	15.2	Comstock	κ 2 N	4.3	4.20	
	15.5	Bohlin		4.2		
	15.8	Hadden		4.0		
	16.3	Wendell	Photometer	4.29		
23	5.6	Nijland	With opera-glass	3.93		
	5.7	Nijland	With naked eye	4.06		
	7	Anckermann		4.1		
	7.1	Luizet		3.8		
	7.4	Honnorat		4.2		
		Glasenapp		3.9		
		Solá		4.2	3.9	
		Sharp		3.8		
		Ventosa	N = ν	4.0		
	7.5	Verschaffel	κ, ρ	3.9		
	7.5	Pola	2 observers	3.7		
	7.5	Riccò	< κ	< 4.03		
	7.8	Riccò	Photometer: 725 PPD, ϵ	4.31	4.09	
	8	Köhl	N = ν		3.93	

* Clouds.

HUSSEY'S MEASURES OF THE OΣ DOUBLE STARS.

S. W. BURNHAM.

FOR POPULAR ASTRONOMY.

One of the most important and interesting contributions of practical astronomical work has just been issued by the great Observatory at Mt. Hamilton, as Volume V of the Publications of the Lick Observatory. This quarto volume of 227 pages contains the re-observation and measurement by Professor Hussey of all the double stars of the first edition of the Poulkowa Catalogue of 1843. Each of the pairs has been measured on an average of three nights with either the 12-inch or the 36-inch refractor, the most difficult of these objects, of course, being observed with the large instrument. The measures were made principally from 1897 to 1900, and, for the most part, all the measures of each star were made in the same year. It is well known that in the second edition of 1850 of the Poulkowa Catalogue many of the stars of the first catalogue were rejected, some because the suspected elongation was not confirmed by subsequent examinations; some because the companion star was too distant for the limit then adopted, or too faint for accurate measurement; and some because they had been found to be identical with previously known pairs in the catalogues of W. Struve, Herschel and others. These rejected numbers amount altogether to 106 stars. The original number of the OΣ stars was 514, but other new pairs were found from time to time, and the total number was finally extended to 547.

Hussey has accounted for all these stars, rejected and otherwise, and arranged them in this general catalogue in numerical order, with a table at the end of the volume giving them in order of right ascension with positions for 1900, so that any star can be found by its number or place. He has collected with remarkable thoroughness substantially all the published measures of each pair, and placed them in chronological order, with a reference to the place of publication. One can see at a glance whether or not there is any relative motion, and generally what the change is in the last sixty years, where there is change in the components from proper or orbital motion. The notes accompanying each star are complete, and give all that is worth mentioning concerning the character and history of the pair. They are models of completeness for brevity. When necessary they are illustrated by diagrams showing the relative change in the components.

The pairs rejected as single have all been carefully examined with the great telescope, and in each instance no elongation detected under favorable conditions. Many of these stars had been previously examined by the writer with the same telescope and with Chicago 18½-inch with the same result, but it is always possible that a star of this class may be really double, though so close from the rapid motion of the components that at a given time it is single with the largest aperture. As many of these stars have been watched more or less at intervals in the last thirty years, without showing any signs of duplicity, in first-class refractors, it is safe to say that in all probability the original observation which led to their being placed in the Poulkowa Catalogue was a mistake, and the supposed elongation not real.

Of the other class of wide pairs, although not likely to be of any interest as physical double stars, many of them were in need of measurement, as some depended upon perhaps a single observation of Madler made more than half a century ago. Some of them were placed on the working list of neglected pairs prepared by the writer for observation at the Yerkes Observatory, not knowing at that time that Hussey's plan embraced all these stars. My work in this direction was, of course, discontinued after receiving this volume, as there would be no excuse for duplicating work already so carefully and well done.

In the course of these observations Professor Hussey found new components to five of the Poulkowa stars, and two of these, OΣ 351 and OΣ 476, seem to be remarkable objects visually, and likely to be remarkable hereafter as physical systems. The known components of the first pair are only 0″.6 apart, while one of them is composed of two stars with a distance of only 0″.3. In the other case the OΣ components have a distance of 0″.54, and the smaller of these is a close pair with a distance of 0″.15. These are the closest triple stars known, and are certain to be interesting physical systems, and perhaps in rapid motion. Discoveries of this kind must necessarily be made with large refractors, and while it is possible that these stars are more readily seen now than heretofore, it is certain that they are beyond the grasp of all or nearly all the instruments used for the measurement of these stars in former years.

The Director of Lick Observatory, and the authorities of the University of California have earned the thanks of the astronomical world for the prompt publication of this beautiful volume. The printer's work has been so well done that it may be said to represent the highest art in this class of composition.

The arrangement of the matter, and the selection of the various kinds of type make a volume both convenient and pleasant to use. The plan generally is that adopted in the General Catalogue of the β Stars issued as Vol. I of the Publications of the Yerkes Observatory.

This volume will practically take the place of all former works relating to this subject matter, since it contains all that is needed in the earlier catalogues and publications. It should prevent hereafter much waste of time in duplicating measures, and observing pairs for which no measures, for many years, are needed. The stars which are shown to be relatively fixed, or where the change is slow, will need no further attention for at least a quarter of a century. On the other hand, those in rapid orbital motion should be measured by one of the large telescopes at short intervals, some of them every year. For some of these binaries, new orbits have been computed, based upon the new and later measures. Among others is an orbit of δ Equulei, from which it appears that a period of 5.7 years will satisfy the measures as well or better than the 11.4-year period heretofore supposed to be the true time. Should this shorter period prove to be correct —and the prima facie case made seems to be a strong one—it will be the most rapid binary now known. If this pair is carefully watched and measured several times each year when the apparent motion is most rapid, as it doubtless will be at Mt. Hamilton, it will not require long to determine which of the periods is correct. It is fortunate that micrometrical work, and especially that relating to double stars, is in the hands of two such zealous and expert observers as Hussey and Aitken.

One can imagine the pleasure with which the venerable Otto Struve will examine this work which brings together for the first time in a perfect and permanent form his great discoveries of more than half a century ago. At this time in his life, when his work with the telescope has been concluded, he cannot fail to appreciate the value of this volume as a permanent monument to his memory.

SUPPLEMENTARY REPORT ON NON-EUCLIDEAN GEOMETRY.

GEORGE BRUCE HALSTED.

For Popular Astronomy.

When at the Columbus meeting of the American Association I had the honor of making a 'Report on Non-Euclidean Geometry,'

it was mentioned that my own 'Bibliography of Hyper-space and Non-Euclidean Geometry,' in the *American Journal of Mathematics* (1878) giving 81 authors and 174 titles, when reprinted in the collected works of Lobachevski (Kazan, 1886) gives 124 authors and 272 titles; while Roberto Bonola and just given (1899) a 'Bibliography of the Foundations of Geometry in relation to Non-Euclidean Geometry,' containing over 350 titles with some repetitions.

Bonola in 1900 finished a second part of this bibliography in which the single section headed 'Historical, Critical, and Philosophical Writings,' gives 96 authors and 150 titles. It thus becomes very evident that a most important function of your reporter is the selection of what writings to bring forward for especial mention as of paramount importance and typical of the main stream of advance.

In the Columbus report I particularly stressed the work of two authors whom I brought forward together and to whom I devoted about a quarter of that report.

The report first appeared in *Science* for October 20, 1899, and you may imagine that it was reassuring when on October 22, (old style), 1900, the Commission of the Physico-Mathematical Society of Kazan found the scientific merits of the works of these authors, A. N. Whitehead and Wm. Killing equal for the great Lobachevski prize and had to decide between them by the drawing of lots.

In his report on the work of Whitehead, Sir Robert Ball says of the 'Universal Algebra':

"Several other writers, to whom of course Mr. Whitehead makes due acknowledgment, have approached the study of non-Euclidean geometry by the aid of Grassmann's methods, but the systematic and most instructive development of the subject in book VI. is, I believe, new, as are also many of the results obtained.

"The superiority of Whitehead's methods appears to lie in the two following features:

"1°. That he can treat n dimensions by practically the same formulæ as those used for two or three dimensions.

"In this I think he has made a considerable advance upon the methods, ingenious and beautiful as some of them no doubt are, which have been used by previous investigators.

"2°. The various kinds of space, parabolic, hyperbolic and elliptic (of two kinds), present themselves in Whitehead's methods quite naturally in the course of the work where they appear

as the only alternatives when certain assumptions have been made.

"Moreover the results have been obtained in such a way that it is easy for the reader to develop for one of the other spaces properties treated out in full for one space only.

"The book deserves in the highest degree the attention of the student of modern mathematical methods, and it marks so great an advance that it is, in my judgment, well worthy of the important prize in view of which this report is prepared.

"Mr. Whitehead's memoir on geodesics in elliptic space appears to me to indicate great power in dealing with a very difficult problem. I believe it to be of much importance, as the geodesics in the generalized space conceptions had been but little studied."

In the corresponding report on the work of Killing, Professor Engel, of Leipsig, says of the 'Grundlagen der Geometrie':

"This work is, from the first to the last page, a justification and detailed development of the circle of ideas which we are accustomed to understand under the expression 'non-Euclidean geometry'."

"Already so many preliminary questions have been settled," said Killing in the preface to his first volume, "that the final solution can be hoped for at a not too distant time."

"These words written in 1893," says Engel, "have meanwhile most recently (1890) found a highly striking confirmation in many directions through Hilbert's investigations.

"The geometries possible with the Euclidean, namely the Lobachevski-Bolgaian, the Riemannian and the elliptic, Killing develops, each for itself, in Euclidean way up to a certain grade.

"Also it should not be forgotten that Killing was the first, who (1879, *Crelles Journal*, Bd. 83) made clear the difference between the Riemannian and the elliptic space (or as he calls it, the Polar form of the Riemannian.)

"The fourth section treats the Clifford-Klein space-forms, in whose investigation Killing himself has taken a conspicuous part (by a work in Bd. 39 of the *Mathematische Annalen*, 1891). The great importance of these space-forms rests upon this, that they show with especial clearness, what a mighty difference it makes whether we, from the beginning, assume the geometric axioms as valid for space as a whole or merely for an every way bounded piece of space. In the first case we obtain, besides the Euclidean, only the three previously mentioned non-Euclidean space-forms.

"In the second case appears also a manifoldness, at present not yet dominated, of different space forms.

"The treatment of continuity and the ratio-idea in Euclid gives occasion for a nearer investigation of the so-called Archimedes' Axiom.

"Finally, as the first attempt to illuminate in conjunction all the different questions which have grouped themselves about the problem mentioned, and to collect all the means, which numerous mathematicians, and not least the author himself, have made for solving the problem, this work will for long retain its value.

"That precisely the founding of geometry since the appearance of this book has been advanced in a wholly unexpected way by Hilbert, cannot lessen Killing's merit. His work remains still by far the best means for mastering the researches which have appeared in this realm up to 1898." These interesting extracts I take from the Russian pamphlet just issued at Kazan and furnished me by my friend Professor Vasiliev.

In his paper "Ueber Nicht-Euklidische und Linien-Geometrie" (Greifswald, 1900), Professor E. Study voices a profound truth when he says: "The conception of geometry as an experimental science is only one among many possible, and the standpoint of the empiric is as regards geometry by no means the richest in outlook." "For he will not, in his one-sidedness, justly appreciate the fact that in manifold and often surprising ways the mathematical sciences are intertwined with one another, that in truth they form an indivisible whole."

"Although it is possible and indeed highly desirable, that each separate part or theory be developed independently from the others and with the instrumentalities peculiar to it, yet whoever should disregard the manifold interdependence of the different parts, would deprive himself of one of the most powerful instruments of research."

"This truth, really self-evident yet often not taken to heart, applied to Euclidean and non-Euclidean geometry, leads to the somewhat paradoxical result, that, among conditions to a more profound understanding of even very elementary parts of the Euclidean geometry, the knowledge of the non-Euclidean geometry cannot be dispensed with."

That the world has caught one deduction from this deep idea, is shown by the fact of the almost simultaneous appearance of two text-books, manuals for class use, to make universally attainable this necessary condition for any thorough understanding of any geometry, even the most elementary; two intended, available popular treatises on this ever more essential non-Euclidean geometry.

THE LEONIDS FOR 1901.

W. W. PAYNE.

The watch for the Leonids of this year, at Goodsell Observatory of Carleton College, Northfield, Minn., was chiefly made on the evening of Nov. 14 and the morning of the 15th. The sky throughout the night was almost perfectly clear. The temperature ranged from + 28° in the evening to about + 20° in the morning and the wind blew all night steadily and strongly from the direction west of north, with a nearly stationary barometer at 29.435.

The watch at this place was planned to begin at midnight, although occasional looks at the sky were made during earlier hours. As the constellation of Leo came up, the few clouds on the eastern horizon partly obscured the stars, and but few Leonids were seen for the first half hour after twelve o'clock. After this the coming of the shower was apparent, and the watch was eagerly taken up by about thirty observers, consisting of the professors of the Observatory, some members of the Senior class of the College, and the entire class in college astronomy and some other students.

The chief thing aimed at was the careful observation of the Leonids and the charting of as many of them as possible whose paths could be located definitely with reference to neighboring stars, and to notice any peculiarities of trails belonging to bright meteors. This plan was well carried out considering the experience of the observers. We will give some of the results apparent from the records that have come in for review, before the reduction and final charting of all is done, that our readers may compare the preliminary work here with other similar work at other places.

One observer gave attention to a count of the meteors for 4^h, 12^m during the period of 5^h 20^m from 12^h 30^m to 5^h 50^m. In this interval 621 meteors were seen. They were largely Leonids. For an hour after 3^h 30^m 124 were counted. From 3^h 30^m to 4^h 30^m, 209; from 4^h 30^m to 5^h 30^m, 187. During this last period another observer counted 100 meteors in 27 minutes, none of which were less in brightness than that of a second magnitude star. If now, we suppose that there were as many faint meteors in the fourth part of the sky observed as those that were seen equal to a second magnitude or brighter, it is easy to estimate the fall of meteors at this station, by the hour, during the thickest part of the

shower. Heretofore observers of the Leonids have claimed that all the meteors under the second magnitude in brightness were between one and two times as many as all those of a second magnitude or above. If we should say that all those below the second magnitude, were equal in number to those of the second magnitude and above, it would make the estimate on the basis of one observer, 400 per hour, in the thickest of the shower, or for four observers trying to see the whole sky at once about 1,600 per hour. This is the lowest estimate of the relation of the visible to those not seen that we have noticed in the records at hand from the observations of the Leonids of 1866. If we were to use the higher ratio of those seen to those not seen, claimed by some observers, the hourly fall would be more than 2000 instead of the number previously named.

The trails of the Leonids are always interesting because of their color and the swiftness of the meteors that make them. Those who know about the position of the path of the stream where it comes nearest to the orbit of the Earth about the middle of November remember that the two paths are nearly parallel and that the Earth is going one way in its path the great stream of the Leonid meteors is going nearly the opposite way in its path. The velocity of the Earth in its path is about eighteen miles per second, and that of the meteors about twenty-six miles per second. This would make the apparent velocity of the Leonids as they sweep into the Earth's atmosphere about forty-four miles per second, and this fact explains why the Leonids seem to move so swiftly as compared with most others from other radiants.

Astronomers know the vast numbers of meteors belonging to this group are arranged in an enormous stream, the width of which is small compared to its length. Its orbit has its nearest point to the Sun when it meets the Earth's path Nov. 13-15, and its farthest point lies beyond the orbit of the planet Uranus. The Leonid stream makes a complete circuit in this great orbit around the Sun once in about thirty-three years. Ball, in "The Story of the Heavens," gives a neat illustration of this stream, when he likens it to a thread of the finest sewing silk. If we think of the great orbit of the Leonids as an ellipse seven feet long, then this stream of meteors would be a thread of silk on it one and a half or two feet long creeping along in its path to make this great circuit once in thirty-three years. When we think of a thread of finest sewing silk, we do not realize the real depth of this great stream. Astronomers think that the width of this

shoal of meteors cannot be less than 100,000 miles because it requires five hours for the Earth to pass through it. In the same way they think it must be very long, because it takes at least two full years, and probably more, for the stream to pass by the point in the Earth's orbit which is reached by our planet about the middle of November each year.

The years of 1899 and 1900 were very disappointing in regard to the richness of the showers expected, for these were the years for which very brilliant displays were predicted. Why the predictions were not fulfilled is not easy to state briefly, because those who have given most attention to the astronomy of the meteors are not fully agreed as to all the causes. Doubtless this year's display will afford data that will materially aid in settling some questions that need more thorough study.

In regard to the display of this year, we imagine that many astronomers will be taken off their guard. We have already heard from some who freely confess to such a fault, giving the expected reason that they were so discouraged by the experience of the last two years, that almost nothing was anticipated this time. But very likely some good reports will reach us yet for this issue; if not, we certainly expect a good showing in the number for January, 1902.

There were four especially interesting meteors that were observed at Northfield on the morning of Nov. 15. The first was seen by Mr. E. A. Fath at $2^h\ 41^m\ 50^s$ Central Standard time. Its trail was short and located southeast of α Hydra. The remarkable thing about this meteor was its curved path. It swept around through an angle of 120° while it was passing not more than 2° in the general direction of southeast. Its time and trail were both so short that it is difficult to say whether the meteor was a Leonid or not.

At $3^h\ 10^m\ 40^s$ a brilliant Leonid passed through the constellations of the Crater and Hydra, starting from α of the Crater and disappearing near β of Hydra. The trail was brilliant, and it persisted firmly in the same place for about three minutes.

The Leonid that came at $4^h\ 15^m\ 35^s$ was one of startling brilliancy; it began near to Ursæ Majoris and disappeared near γ Cephei. Its train was one of the most persistent observed during the night. It lasted six minutes.

The remaining very brilliant Leonid was the most remarkable of all seen at this station. It was observed at $5^h\ 18^m\ 10^s$. It shot downward from the direction of Leo into Hydra and Puppis. While passing through Hydra it seemed to burst, and

then a series of changes in the trail followed that were very wonderful, attracting the attention of many observers for ten minutes or more. The long trail which lay in the two constellations was caught near its middle point where the explosion seemed to occur and violently driven eastward until the two parts formed a right angle in the western part of the constellation of Monoceros. It then seemed to assume the shape of a great fireball as it moved northward towards the head of Hydra. We, ourselves, watched this brilliant display of Leonid colors and wonderful changes in form for nine minutes. Other good observers whose eyes are more sensitive than ours claimed to see this remarkable trail for twenty-two minutes.

These and other bright meteors will soon appear in charts to be prepared for the pages of this journal later.

Dr. H. C. Wilson, of Goodsell Observatory, exposed two plates covering some more than the "Sickle" in the constellation of Leo for $3^h\ 40^m$ and obtained one interesting trail which is clearly a Leonid. It was expected that more trails would be secured in view of the length of time given to the exposure and the richness of the shower at the time the photographs were taken. But it was a noticeable fact that at no time during the night was a very bright meteor seen very near the radiant, although that point more than any other was under the closest watch. This particular trail obtained on the photographic plate was interesting in two ways: 1st, by comparing it with two plates exposed for Leonids in Nov. 1898 on each of which was obtained a single trail, the three trails when produced were found to intersect in a single point. This seems to be further proof that the radiant of the great stream of Leonid meteors is a point, probably, rather than a spot 2° more or less in diameter. In *Monthly Notices* of February 1899, p. 281, it appears that the Harvard photographs showed converging trails of the Leonids for 1898 with a radiant sharply at right ascension $10^h\ 6^m.8$ Decl. 22° 16′ (1900) within a deviation of 10′. On p. 282 of the same volume it is noted, that the two trails before referred to, photographed by Dr. Wilson, in 1898, intersected in right ascension $10^h\ 6^m$, Decl. 22° 18′. It is now plain that this new trail obtained Nov. 15, 1901, is another proof for the radiant as a point.

The other interesting feature about this photographic trail is the way it looks under low magnifying power. For about one-third of its length it widens out gradually and then more rapidly tapers down to a thin line ending with an arrow head that looks like the work of a skilled artist. In its thickest part, the struc-

ture on either side of the median line is filiamentary like that of the feathery portion of a quill of a bird, only that the fine lines incline forward in the direction of the meteor's path instead of backward as is true in case of a quill. The curious structure of this particular trail obtained on the photographic plate is hard to explain. Possibly others have photographed the same trail, if so, we will be grateful for added information in regard to it.

VISITORS' REPORT ON THE NAVAL OBSERVATORY.

A contest between the scientists of the country on one side and naval line officers on the other, which has been waged for years past and involves the rich prize of the control of the Naval Observatory, has been brought to a critical point by the presentation to Secretary Long of the report of the Board of Visitors to the Observatory, in which the issue is drawn sharply in favor of civil control.

The Board is composed of Charles A. Young, Charles F. Chandler, Asaph Hall, Jr., E. C. Pickering, Professor Ormond Stone, and William R. Harper, all men of national reputation in scientific research. The particular bone of contention of late has been a vacancy in the office of Astronomical Director, and the Board makes the following pointed remarks as applying not only to that but to other less important places in the Observatory:

"It is recommended that no Astronomical Director be appointed at present, as a dual leadership has been found to work unsatisfactorily, and under the existing law the appointment of an astronomer as sole Director of the Observatory—which the Board considers the proper solution of the question—is impracticable. Vacancies should not be filled among assistant astronomers nor among professors of mathematics in the Navy without examination for each vacancy occurring. No distinction should be made between employes of the Observatory and other applicants. The responsibilities of the positions of assistant astronomer and professor of mathematics are distinctly different from those of a computer, although much of the required experience may properly be gained in connection with the latter position and be credited in the examinations for the higher positions.

Oppose Transfer System.

"As far as is consistent with the routine needs of the institution, the duties of the computers should be so arranged as to encourage them to prepare for advancement within the Observa-

tory itself. In no case should appointments be made to the Observatory merely by transfer from other bureaus or offices in the service, nor should appointments ever be made even temporarily without competitive examination."

Applying the principles to practice, the Board decline to name a person to fill the vacant office of assistant astronomer at the Observatory, and instead recommend that the appointment be made after a civil service examination under the auspices of the commission.

Coming to the more important subject of the actual head of the Observatory, which involves the issue between the scientists and the line officers, the Board says:

"As every other prominent Observatory is under the direction of an astronomer, we wish to record our deliberate and unanimous judgment that the laws limiting the superintendency to a line officer of the navy should be changed so as to provide that the official head of the Observatory—perhaps styled simply the director—should be an eminent astronomer appointed by the President, by and with the advice and consent of the Senate, holding this place by a tenure at least as permanent as that of the superintendent of the Coast Survey or the head of the Geological Survey, and not merely by a detail of two or three years' duration.

SHOULD BE RANKING OFFICER.

"Only in this way can there be a continuous and effective policy of administration which will insure astronomical work of a high order. In rank, salary, privilege and prestige he should be superior to any other official on the ground.

"The limitation in the selection of assistants should also be removed, and the assistant once appointed should be secure against detachment or removal except by action, for cause, of the Director.

"The institution should be related to the Navy department, if continued under its control, in some such way as the Royal Observatory at Greenwich is related to the British admiralty. It should be put under the control of the Secretary directly and not through a bureau, as at present."

In conclusion, the Board finds objection to the manner in which appropriations have been made in support of the Observatory, saying that it is not easy to determine what portion of the expenditures pertains properly to astronomical work, what portion to the naval work, and what portion to the improvement

and care of the grounds as a part. The cost of maintenance for the last fiscal year was $108,428 of which amount $21,258 was expended in salaries.—*Washington Post, Nov. 12.*

THE TERCENTENARY OF TYCHO BRAHE'S DEATH.*

The 300th anniversary of Tycho Brahe's death has been celebrated in his native land by a festive meeting of the Academy of Science at which the venerable King Christian was present, and at which orations were delivered setting forth the importance of Tycho's scientific work. At Prague, where he died, the monument over his recently restored tomb in the Teyn Church was again unveiled, and the interest which the citizens of Prague have always shown in the illustrious exile was manifested in various ways. But though Tycho towards the end of his life felt himself neglected in Denmark and left the country in order to enjoy the society of learned and congenial minds elsewhere, he never forgot the land of his ancestors and his birth, and on the titles of his last writings, as on his first, he describes himself as "Tycho Brahe Danus."

The Copenhagen Academy has chosen a very fitting way of doing honor to the memory of the greatest scientific man Denmark has produced by publishing a facsimile reprint of his earliest publication, "De nova stella" (1573). Tycho's four principal works are found in all great libraries and are not unfrequently met with in the lists of second-hand booksellers. But the book on the splendid new star which appeared in Cassiopeiae in November 1572 is so extremely scarce that not a single historian of astronomy had ever seen it or even been able to give the title correctly until the writer of these lines gave an account of it in 1890. Tycho says himself that not many copies were printed and only a few were sent abroad, for which reason he afterwards reprinted the more important parts of it in his larger work, "*Astronomiæ Instauratæ Progymnasmata*," on which he was engaged during the last fourteen years of his life and which was published after his death. But the whole of the original book, as it left the hand of the young author, is of great historical interest, and we are glad to see the fine reprint now issued, as the star of 1572 was so intimately connected with the progress of Tycho's work.

In a short Latin preface and a Danish postscript of thirty pages M. Pechüle, of the Copenhagen Observatory, has given a short

* Extract from article with above title in *Nature*, November 7, 1901.

summary of the origin and contents of the book. Tycho's manuscript was an astronomical, astrological and meteorological almanac for the year 1573, in which he, after lengthy introduction (to the almanac proper), had inserted his essay on the new star, another on the lunar eclipse of December 1573 and a poem to Urania. After a good deal of persuasion by several friends, Tycho allowed the book to be printed in the spring of 1573, omitting, however, the main part of the almanac. It contains 53ff, and has now been exactly reproduced in facsimile, but it has been collated with a MS. copy partly written in Tycho's own hand and preserved in the Imperial library at Vienna, in which way a few corrigenda were noticed which are given at the end of the reprint. The book which, is beautifully got up, also contains a specimen of Tycho's handwriting and a copy of a very fine portrait, drawn with pen and ink, found in the Royal collection of engravings at Copenhagen and by some ascribed to the Dutch engraver Goltzius, by others to the painter Gemperlin of Augsburg, who came to Denmark with Tycho in 1575 and afterwards painted the well-known portrait on his mural quadrant. To anyone acquainted with the contemporary literature on the new star and on comets this book will be of great interest, as it gives a very sober account of the startling celestial phenomenon which had given rise to a host of more or less worthless pamphlets and books, and shows that the want of parallax and motion proves the star to belong to the region of the fixed stars. At the same time, it is interesting to see that the author, who was destined afterwards to give the death-blow to the Aristotlelean idea of the atmospheric origin of comets, was still a believer in this doctrine when he wrote his first book, but also that he was already then thoroughly aware that the great desideratum of astronomy was an extensive series of observations which he hoped to be able to supply if health permitted and the necessary means were granted him.

Scania, the province east of the Sound, where Tycho was born, and the little island of Hveen, on which his Observatory stood, formed parts of the kingdom of Denmark from before the dawn of history and till 1658, when they were torn from the country which had not sufficiently valued him and incorporated in Sweden. It is therefore natural that the recent anniversary of his death also attracted attention in Sweden, and in honor of the day the Physiographic Society of Lund has published a *Festskrift* (20 pp., 4to., with three plates), in which Professor Charlier, of Lund, gives an account of the recent exploration of the scanty

remains of Tycho's buildings on the island. The foundations of Uraniburg were laid bare, as also the floors of the half-subterranean Observatory Stellæburgum (Stjerneborg), but scarcely anything was found more than what the clergyman Ekdahl unearthed in 1823. It has repeatedly, in 1823, in 1868 after the examination of the site by d'Arrest, and now again on the present occasion, been pointed out that "something ought to be done" to protect the ruins from wind and weather, and we may add from relic-hunters also. If this was desirable formerly, when Hveen was a lonely place to which nobody ever went, it has become infinitely more important now, as the island seems to have become the common resort of Sunday trippers from both shores of the Sound, and it would certainly be safer to cover up the foundations again than to leave them unprotected. It has recently been suggested that the Observatory might easily be rebuilt from Tycho's detailed and illustrated description and on the existing foundations and floors of the crypts, and no doubt this would be quite possible. But we confess we should prefer to see a large shed erected over the few stones that are left so that these venerable ruins could remain undisturbed. Most people would prefer looking at the ruins of Kenilworth Castle to walking through a sham castle erected on them and absorbing them.

PLANET NOTES FOR DECEMBER.

H. C. WILSON.

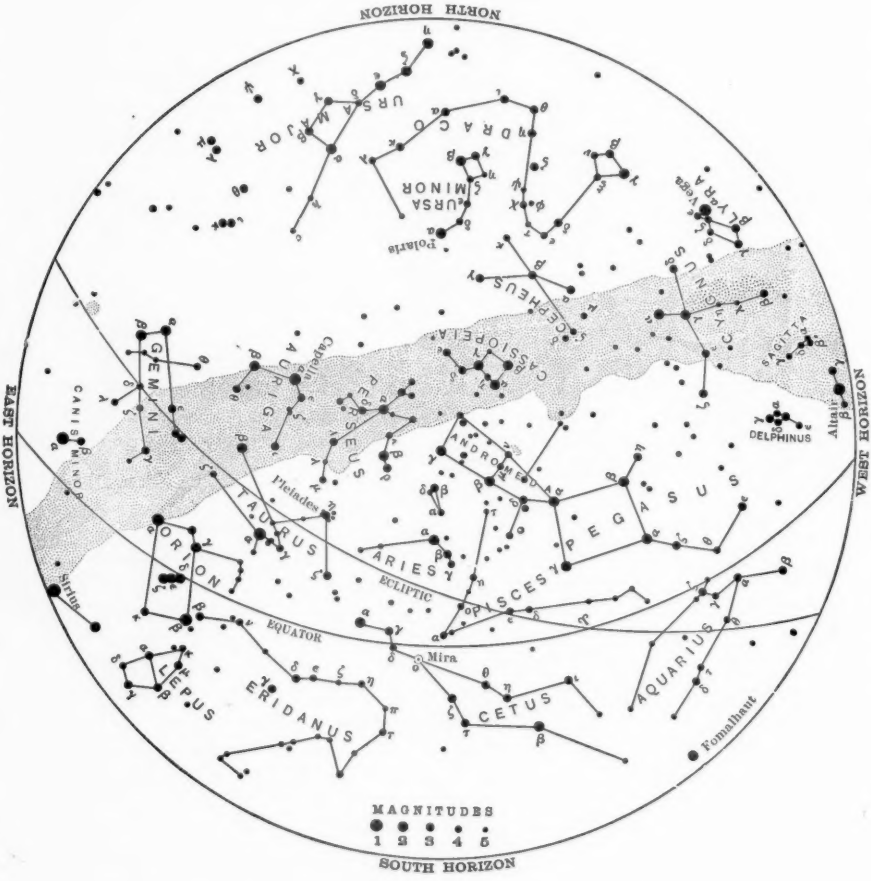
Mercury, passing now around to the farther side of its orbit from the Earth, will not be visible during December.

Venus will be at greatest elongation, east from the Sun 47° 19′ on Dec. 4. Her brilliancy now is about three-fourths of that at maximum and will increase rapidly during the month. She is now a very beautiful object in the southwestern sky, seen best before six o'clock in the evening, but at so low an altitude that telescopic observations are worthless. The phase is now almost exactly half and will decrease to a crescent of less than one-third the apparent diameter of the planet at the end of the month. The movement of Venus past the two bright planets, Jupiter and Saturn, during the past month must have caught the eye of the most casual observer, as the triangle formed by the three brilliants went through its series of changes of form and size. During this month Venus will leave her two companions behind, to be soon lost to sight in the twilight glow.

Mars has been lagging so far behind Venus as to be hardly noticed and is practically lost to sight for the next six months. He will overtake Saturn Dec. 14 and Jupiter Dec. 17 and so may be brought into notice again for a few days by his proximity to his more brilliant neighbors.

Jupiter and *Saturn* will be visible between five and six o'clock in the evening, but so near the southwestern horizon that telescopic observations will be impossible.

Uranus will be at conjunction Dec. 9 and therefore is invisible.



THE CONSTELLATIONS AT 9 P. M., DECEMBER 1, 1901.

Neptune will be at opposition Dec. 22 and so is in best position for observation. The planet is not visible to the naked eye but may be found with a telescope, in the constellation Gemini. Its position Dec. 1 is: $6^h\ 02^m\ 46^s$; Decl. $+\ 22°\ 15'$ and on Dec. 31 will be: R. A. $5^h\ 59^m\ 11^s$; Decl. $+\ 22°\ 15'$.

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.)		Sets.	
		h	m	h	m
Dec. 1-2	Last Quarter	11	12 P. M.	12	17 P. M.
10	New Moon	7	05 A. M.	4	32 "
18-19	First Quarter	12	56 "	12	41 A. M.
24-25	Full Moon	4	13 P. M.	7	37 "

Occultations Visible at Washington.

Date. 1901.	Star's Name.	Magnitude.	IMMERSION. Washington M.T. h	m	Angle f'm N pt.	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
Dec. 5	α Virginis	1.2	14	05	72	14	52	330	0	46
8	28 Libræ	6.0	3	41	24	4	03	343	0	22
14	B.A.C. 7087	6.2	8	18	46	9	12	273	0	53
19	62 Piscium	6.0	8	34	139	8	55	172	0	21
19	δ Piscium	4.6	8	36	74	9	51	238	1	15
27	60 Cancri	5.7	9	00	111	10	01	274	1	01
27	κ Cancri	5.0	16	02	96	17	13	315	1	11
29	36 Sextantis	6.6	12	05	166	12	47	240	0	42

ASTEROID NOTES.

Numbering of New Asteroids.—The following asteroids discovered this year have received permanent numbers:

Number.	Preliminary Designation.	Discovered.	Discoverer.
(464)	1901 FV	Jan. 9	Wolf
(465)	1901 FW	Jan. 13	Wolf
(466)	1901 FX	Jan. 17	Wolf-Carnera
(467)	1901 FY	Jan. 9	Wolf
(468)	1901 FZ	Jan. 13	Wolf
(469)	1901 GB	Feb. 13	Wolf-Carnera
(470)	1901 GJ	Apr. 21	Carnera
(471)	1901 GN	May 18	Carnera
(472)	1901 GP	July 11	Carnera

Ten others discovered during the same period of time were not observed enough to permit certain determinations of their orbits. The one denoted GH was found to be identical with number (449). Number (470) has received the name Kilia.

New Asteroids Discovered.—Since our note in October the following new discoveries of asteroids have been announced in *Astr. Nach.* Nos. 3740 and 3746:

	Local M. T.	h	m	R. A. h	m	s	Decl. °	′	Daily Motion s	′	Mag.
1901 GT	Sept. 19	10	50.4	22	8	28	+ 3	29	−36	−5	12.0
GU	21	13	44.6	0	25	04	+18	03	−48	−4	11.8
GV	Oct. 11	10	26.6	1	58	24	− 0	30	−48	−9	11.5
GX	11	13	11.7	23	28	44	− 3	10	−48	−9	13
GY	11	10	19.5	23	54	36	− 1	11	−48	−5	12.8
GZ	13	13	0.9	1	49	15	+18	09	−64	−2	12.5
HA	13	11	39.5	23	32	00	− 5	15	−36	−4	13.0

GT was discovered by Wolf at Heidelberg, GU by Carnera at Heidelberg, GV by Villiger at Munich, GZ by Kopff at Heidelberg and GX, GY and HA by Carmera and Kopff jointly.

Elements and Ephemeris of Asteroid (175) Andromache.—In *A. N.* 3745 Dr. Berberich gives the following elements and ephemeris of Andromache for December. The magnitude of the planet at opposition is 12.6:

EPOCH 1901 DEC. 25.0 BERLIN M. T.

$M = 97^\circ\ 38'\ 20''.2$
$\omega = 301\ 41\ 27\ .3$
$\Omega = 25\ 23\ 12\ .9$ 1900.0
$i = 3\ 10\ 35\ .9$

$\phi = 11^\circ\ 8'\ 37''.6$
$\mu = 611''.7640$
$\log a = 0.5089485$

EPHEMERIS FOR BERLIN MIDNIGHT.

	h	m	s	°	′		
Dec. 1	5	47	21	+27	06.5	0.5293	0.3863
3		45	40	27	07.4		
5		43	56	27	08.1	0.5302	0.3847
7		42	10	27	08.6		
9		40	22	27	08.9	0.5311	0.3840
11		38	33	27	09.0		
13		36	44	27	09.0	0.5319	0.3842
15		34	54	27	08.7		
17		33	5	27	08.1	0.5328	0.3853
19		31	16	27	07.5		
21		29	28	27	06.6	0.5336	0.3872
23		27	42	27	05.6		
25		25	58	27	04.4	0.5345	0.3900
27		24	17	27	03.0		
29	5	22	38	+27	01.4	0.5353	0.3937

Ephemeris of Asteroid (172) Baucis.—The following ephemeris computed by L. Fabry is given *Bulletin Astronomique* Nov. 1901.

Paris Midn.	N. A.			Decl.		log Δ	log *r*
1901.	h	m	s	°	′		
Dec. 1	5	13	06	+39	13.4	0.1700	0.3855
3		10	31	39	10.8	0.1694	0.3860
5		07	54	39	07.2	0.1692	0.3864
7		05	16	39	02.7	0.1693	0.3868
9		02	38	38	57.2	0.1697	0.3873
11	5	00	01	38	50.7	0.1704	0.3877
13	4	57	26	38	43.3	0.1715	0.3881
15		54	54	38	35.0	0.1729	0.3886
17		52	25	38	26.0	0.1746	0.3890
19		50	02	38	16.4	0.1766	0.3894
21		47	42	38	06.0	0.1789	0.3899
23		45	28	37	54.8	0.1815	0.3903
25		43	23	37	43.1	0.1844	0.3907
27		41	23	37	30.8	0.1875	0.3911
29		39	31	37	18.3	0.1909	0.3915
31		37	47	37	05.3	0.1945	0.3919
1902.							
Jan. 2		36	15	36	52.2	0.1984	0.3923
4		34	47	36	58.9	0.2025	0.3927
6		33	29	36	25.4	0.2068	0.3931
8		32	19	36	11.8	0.2112	0.3936
10		31	18	35	58.2	0.2158	0.3940
12		30	26	35	44.6	0.2206	0.3944
14		29	44	35	31.1	0.2256	0.3948
16	4	29	11	+35	17.7	0.2307	0.3952

Magnitude of the planet at opposition Dec. 9, 10.6.

Ephemeris of Asteroid (444) Gyptis.—The following ephemeris computed by L. Fabry is given in *Bulletin Astronomique* Nov. 1901:

Paris midn. 1901	R. A. h m s	Decl. ° ′	log Δ	log r
Dec. 1	4 56 06	+9 08.1	0.2250	0.4225
3	54 14	9 00.6	0.2256	0.4231
5	52 22	8 53.7	0.2266	0.4237
7	50 32	8 57·3	0.2278	0.4243
9	48 42	8 41.5	0.2293	0.4249
11	46 54	8 36.2	0.2311	0.4255
13	45 07	8 31.6	0.2332	0.4260
15	43 24	8 27.5	0.2355	0.4266
17	41 43	8 24.1	0.2381	0.4272
19	40 06	8 21.4	0.2410	0.4278
21	38 32	8 19.3	0.2441	0.4284
23	37 03	8 17.8	0.2474	0.4290
25	35 39	8 16.8	0.2509	0.4296
27	34 18	8 16.4	0.2547	0.4302
29	33 03	8 16.7	0.2587	0.4308
31	4 31 54	+8 17.5	0.2628	0.4314

Magnitude at opposition Dec. 6: 11.0.

VARIABLE STARS.

New Algol Type Variable 78.1901 Cygni.—Mr. A. Stanley Williams announces this new variable in *Astr. Nach.* No. 3740. Its normal magnitude is 10.0, but at minimum it falls nearly to 12.0. The position of the star for 1855 is

$$\text{R. A.} = 20^h\ 18^m\ 04^s.0;\quad \text{Decl.} = +42^\circ\ 46'.4$$

An approximate determination of the elements of its variation gives

$$\text{Minimum} = 1901\ \text{Sept.}\ 7\ 9^h\ 43^m\ \text{Gr. M T.} + 3^d\ 10^h\ 49^m\ \text{E.}$$

For about $3^d\ 2^h\ 19^m$ it remains constant at 10.0 mag., then diminishes in $3^h\ 30^m$ to 12 mag., where it remains unchanged for 50^m; it then recovers its normal brightness in $4^h\ 10^m$, the whole change occupying about $8^h\ 30^m$.

Variable Stars of Short Period not of the Algol Type.

	Minimum. d h	Maximum. d h		Minimum. d h	Maximum. d h
S Sagittæ	Dec. 1 15	Dec. 5 1	ζ Geminorum	Dec. 14 7	Dec. 19 7
T Vulpeculæ	2 2	3 12	W Geminorum	15 7	17 22
Y Sagittarii	2 19	4 14	T Vulpeculæ	15 11	16 21
η Aquilæ	3 12	.....	δ Cephei	16 23	18 14
X Cygni	3 22	10 17	η Aquilæ	17 21	.....
W Virginis	4 0	12 5	T Vulpeculæ	19 20	21 6
ζ Geminorum	4 4	9 4	β Lyræ	19 23	23 1
δ Cephei	6 6	7 21	X Cygni	20 7	27 2
T Vulpeculæ	6 12	7 22	W Virginis	21 6	29 11
X Sagittarii	6 18	9 15	δ Cephei	22 8	23 23
β Lyræ	7 1	10 3	W Geminorum	23 1	25 16
W Geminorum	7 13	10 4	T Vulpeculæ	24 6	25 16
S Sagittæ	10 0	13 10	ζ Geminorum	24 11	29 11
η Aquilæ	10 17	.....	η Aquilæ	25 1	.....
T Vulpeculæ	10 23	12 9	β Lyræ	26 10	29 15
T Monocerotis	11 23	19 21	δ Cephei	27 17	29 8
δ Cephei	11 15	13 6	T Vulpeculæ	28 17	30 2
β Lyræ	13 12	16 17	W Geminorum	30 18	Jan. 2 9

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours.]

U Cephei.

	d	h
Dec.	1	21
	4	8
	6	20
	9	8
	11	20
	14	8
	16	19
	19	7
	21	19
	24	7
	26	19
	29	7
	31	18

Algol.

Dec.	2	14
	5	11
	8	7
	11	4
	14	1
	16	22
	19	19
	22	16
	25	12
	28	9
	31	6

λ Tauri.

Dec.	1	4
	5	3
	9	2
	13	1
	16	23
	20	22
	24	21
	28	20

R Canis Maj.

Dec.	1	23
	3	21
	4	5
	5	9
	6	12
	7	15
	8	18
	9	22
	11	1
	12	4

R Can. Maj. Cont.

	d	h
Dec.	13	18
	14	11
	15	14
	16	17
	17	21
	19	0
	20	3
	21	6
	22	10
	23	13
	24	16
	25	19
	26	23
	28	2
	29	5
	30	8

S Cancri.

Dec.	2	5
	11	17
	21	4
	30	16

δ Lybræ.

Dec.	2	20
	5	4
	7	12
	9	20
	12	4
	14	12
	16	20
	19	3
	21	11
	23	19
	26	3
	28	11
	30	19

U Coronæ.

Dec.	4	0
	7	11
	10	22
	14	9
	17	20
	21	7
	24	18
	28	5
	31	16

Z Herculis.

	d	h
Dec.	1	3
	3	2
	5	3
	7	2
	9	3
	11	2
	13	3
	15	2
	17	2
	19	1
	21	2
	23	1
	25	2
	27	1
	29	2
	31	1

V[2] Cygni.

Dec.	1	5
	7	5
	13	6
	19	5
	25	5
	13	5

U[3] Cygni.

Dec.	1	10
	6	0
	10	13
	15	3
	19	17
	24	7
	28	20

W Delphini.

Dec.	4	3
	8	23
	13	18
	18	13
	23	9
	28	4

Y Cygni.

Dec.	2	2
	3	8
	5	2
	6	8
	8	1
	9	8

Y Cygni Cont.

	d	h
Dec.	11	2
	12	8
	14	1
	15	8
	17	2
	18	8
	20	1
	21	8
	23	2
	24	8
	26	1
	27	8
	29	2
	30	8
	32	1

S Antliæ.

Period $7^h\ 46^m.8$

Dec.	1	21
	2	21
	3	20
	4	19
	5	19
	6	18
	7	17
	8	17
	9	16
	10	16
	11	15
	12	14
	13	14
	14	13
	15	12
	16	12
	17	11
	18	10
	19	10
	20	9
	21	8
	22	8
	23	7
	24	6
	25	6
	26	5
	27	4
	28	4
	29	3
	30	3
	31	2

Erratum.—In POPULAR ASTRONOMY for November, No. 89, page 518, tenth line from top, for U Lyræ read W Lyræ. R. O'H.

Maxima of U Pegasi.

[Period $4^h\ 29^m\ 8^s$; the minimum takes place $2^h\ 15^m$ after the maximum.]

	d	h		d	h		d	h		d	h
Dec.	1	19	Dec.	9	21	Dec.	17	22	Dec.	25	19
	2	26		10	19		18	21		26	22
	3	21		11	22		19	19		27	21
	4	19		12	21		20	22		28	19
	5	22		13	19		21	21		29	22
	6	21		14	22		22	19		30	21
	7	19		15	21		23	22		31	19
	8	22		16	19		24	21			

Maxima and Minima of Variable Stars.

	Maxima.			Maxima.			Minima.	
Dec.	1	R Ceti	Dec.	15	R^2 Hydrae	Dec.	1	X Centauri
	1	R^2 Sagittarii		16	R Andromedae		1	S Pegasi
	2	U Cygni		18	V Virginis		3	U Monorcerotis
	2	R Sculptoris		19	W Scorpii		3	V Boötis
	3	Z Ophiuchi		20	S^2 Aquarii		5	L^2 Puppis
	4	R Pegasi		20	U Arietis		12	U Virginis
	5	X Hydræ		20	S Vulpeculae		13	U Orionis
	5	V Cancri		20	U^2 Herculis		13	R Vulpeculae
	6	T Camelopardi		21	U Monocerotis		14	R Lyrae
	6	T Centauri		21	U Sculptoris		15	W Boötis
	7	V Cephei		21	R^5 Capricorni		15	S Herculis
	7	T Leporis		22	U Persei		17	η Geminorum
	9	R Aurigæ		22	T Aquarii		17	W Monocerotis
	10	R^2 Virginis		23	X Cassiopeiae		19	R Virginis
	11	R Sagittae		24	X Ceti		20	*l* Carinae
	12	X Pegasi		25	U Eridani		24	R Delphini
	12	R Microscopii		26	T Pavonis		25	T^2 Cygni
	13	S Ceti		30	V Persei		28	R Tauri
	14	S Lyncis		31	R Lacertae		29	S Piscium
	15	R Persei					29	R Centauri
	15	R Scorpii					29	W Cygni
	15	V Librae					29	X Herculis

Observations of Nova Persei.—The following observations on Nova Persei were made after April 1st with a field glass magnifying four and a half times. Mostly by the Argelander method. Since receiving the last number of POPULAR ASTRONOMY, I have reduced the observations using the values there published for comparison stars.

1901.	Hour.	Mag.	
Feb. 25	7:00	1.00	
26	9:00	1.34	
27	9:30	2.16	
28	9:00	2.05	
Mar. 1	11:00	2.40	Doubtful. Partly clouds.
6	9:00	3.05	Color distinctly reddish.
12	10:00	3.31	
16	9:30	3.72	
22	7:15	4.70	
23	8:30	4.09	
30	7:45	3.99	
Apr. 13	8:00	4.70	Doubtful. Sky hazy.
27	8:00	4.26	Poor.
28	8:15	5.52	
May 3	8:30	5.85	Poor.
6	8:30	5.80	
7	8:15	4.92	Too near horizon for accuracy.
8	8:15	5.35.	" " " " "

GEORGE L. JONES.

MEDFORD, Mass.

OBSERVATIONS OF NOVA PERSEI.

1901.	Gr. M. T.	Comparisons.	Est. Mag.	Ob.	Remarks.
	h				
Feb. 21	16.0	Nova nearly as bright as Capella	0.6	*	
25		Nova = Pollux	1.3	W	
"	13.5	Nova = Pollux	1.3	F	
26	15.0	Pollux Nova Castor	1.45	WF	
27	15.0	Nova = α Persei	1.9	W	At one time it seemed a little brighter than α Pers.
28	12.0	Bellatrix Nova α Pers.;	1.9	F	
"	15.0	Nova 2 α Pers.	1.7	W	
Mar. 2	14.0	Nova = β Pers.	2.3	F	Algol at maximum.
"	14.5	α Pers. 2 Nova 2 β Pers.	2.1	W	
5	15.5	β Pers, 2 N 3 ε Pers.; N = ι Aur.	2.6	W	Nova redder than on previous nights. Algol at maximum.
6	13.0	Nova 2 δ Pers.; Nova 1 γ Pers.	2.9	W	
12	16.5	δ Pers. 2 Nova 4 γ Pers.	3.4	W	
16	12.5	κ Pers. 2 N 2 ι Pers.; ν 1 N	4.1	F	
"	13.8	κ 1 N; ν 2 N 1 ι	4.1	F	
"	14.5	Nova = ν Pers.; Nova 2 κ Pers.	3.9	W	
"	15.6	Nova 1 ν Pers.; Nova 2 κ Pers.	3.8	W	Opera glasses.
17	14.2	δ 3 N 2 ν; N 2 η	3.6	F	
"	14-15	N 2 ν Pers.; N 2 κ; N 2 η	3.7	W	Opera glasses.
18	12.2	N 1 ν Pers.; N 1 η Pers.	3.8	W	" "
"	14.8	N = ν Pers.; N 1 η Pers.	3.9	W	" "
19	14.0	N 1 *l* Pers.	5.0	F	Misty, opera glasses.
21	13.0	Nova = ξ Pers.	4.1	W	
"	13.0	ι 1 N : N 2 *l*	4.5	F	
"	14.5	ι 3 N 1 *l*	4.8	F	
"	16.0	ψ 1 N 2 *l*; ψ N 37 H	4.6	W	37 Hagen's Chart I.
22	13.5	ν N *l*	4.5	W	Opera glasses.
"	14.8	N = τ Pers.; N 1 ψ	4.1	F	" "
29	15.8	N = 32 H;	4.5	W	Field glasses.
30	13.5	ν 2 N; N 2 or 3 ψ; ι 1 N	4.0	F	
"	13.5	ι 2 or 3 N; N 3 ψ; N 2 σ	4.2	W	
Apr. 10	13.3	N = 25 H	5.4	W	
12	14.5	ψ 1 N; σ 1 N	4.3	W	
"	14.8	κ N *l*	4.6	W	
17	15.1	N 2 *l*; N = 31 H	4.9	W	
26	13.2	25 H 1 N 1 38 H	6.0	F	Moonlight.
27	13.0	ν 2 N 1 or 2 ψ	4.1	F	
"	13.3	ν 3 N; N = or 1 ψ	4.2	F	
"	14.0	N = ψ	4.2	F	
28	13.8	*l* 2 or 3 N; N = or 1 25 H	5.3	F	
29	13.5	*l* 2 N 3 25 H	5.2	F	Nova quite red, difficult on acc't moonlight.
May 3	14.0	*l* 3 N 2 25 H	5.3	F	Low in horizon.
"	14.5	*l* 2 or 3 N	5.3	W	
6	14.0	*l* 2 or 3 N 2 25	5.3	F	
7	13.2	κ 2 N 3 or 4 *l*; ν 3 N	4.5	F	Opera glasses.
"	13.8	κ 2 N 4 or 5 *l*	4.5	F	" "

The preceding list of observations of Nova Persei was made at the Vassar College Observatory by myself and my assistant, Miss Furness. The comparisons were made by the method of sequences The Nova was either placed equal in magnitude to some star or it was compared with two stars preferably one brighter and one fainter. The steps in the latter case represent the relative position of the magnitude of Nova between the magnitudes of the other two stars. In a few cases where only one star was used, the step is estimated at 0.1 mag. The estimated magnitudes which are given in the fourth column were obtained in accordance with this principle.

MARY E. WHITNEY.

* Estimation made by a student.

Nova Persei.—The nova is again attracting the attention of astronomers, not because of its brilliancy, which continues to wane slowly, nor because of the fluctuations of its light—for these have ceased to be at all marked now—but because of the discovery of an exceedingly faint nebula surrounding the star and apparently connected with it. In October we noted the fact that Messrs. Flammarion and Antionadi had found a nebulous aureole around the star in their photographs taken in August. Professor Max Wolf showed that this aureole was not a nebula but was due to the fact that the light of the star is rich in rays for which the lens used was not corrected. He also stated that some of his plates seemed to show that there possibly is a faint and somewhat extended nebula around the star.

On the night of September 20 Mr. G. W. Ritchey of the Yerkes Observatory, photographed the region of Nova Persei with a two-foot reflecting telescope with an exposure of three hours and fifty minutes. The resulting negative shows that a circular area of about 14′ diameter surrounding the star is filled with faint wisps of nebula. The nebulous streaks, are most of them approximately concentric arcs, whether circular or spiral cannot yet be determined. Their arrangement is strongly suggestive of envelopes resulting from a succession of explosions.

And now comes the startling announcement by telegram from Lick Observatory that the more prominent of the nebular wisps are moving so rapidly that the displacement amounts to a minute of arc in six weeks! A telegram from Yerkes Observatory states that a photograph taken there Nov. 9 confirms the motion of the nebular streaks.

This is a most remarkable discovery, and one of the utmost importance in the construction of a theory of the new star. If we interpret the telegrams aright, the nebulous streaks are moving away from the star. The rate of movement is stated of course only very roughly, but carrying the same rate backward to Feb. 21 would bring them very close to the star. This if true adds great weight to the explosion theory of the sudden appearance of the star, but one must be wary of basing any conclusions upon the meager details of the telegrams.

Even if the nebula should have no connection with the star, its rapid motion is of the greatest importance, for hitherto no certain evidence of motion, except in the line of sight, has been detected in the case of any nebula. With such a rapid motion, the distance of the object should be so small that its parallax should be extraordinary, so that in the course of a few months it might be determined from the measurement of a series of photographs.

A later telegram from Yerkes Observatory states that the nebula seems to be expanding in all directions from the star; that this is certainly true of the southern, denser, half.

A photograph taken with the 8-inch photographic refractor at Goodsell Observatory on the nights of Nov. 13 and 14, with a total exposure of nine hours, shows plainly the two outer nebular condensations to the south and southeast of the star and that close to the star to the southwest. The strongest condensation, now about 8′ southeast from the star has certainly moved a full minute of arc from the place where it is shown in Mr. Ritchey's photograph of Sept. 20. It has not moved straight away from the star but at an angle of about — 30° with the radius vector. The streak to the south has moved southward about one-half minute of arc and possibly eastward to an equal or greater extent; the image is so faint that the latter motion is uncertain. The patch of nebula 1′ to 2′ southwest from the star appears to have moved very little.

If we assume that the motion across the line of sight is equal to that in the line of sight, and that the widening of the lines in the spectrum was due to motion of luminous matter to and from us at the same time, we may obtain an estimate of the star's distance and parallax. The measures of the photographs of the spectrum show the width of the bright line at λ 5000 to have been about 40 tenth-meters and, including the dark companion on the more refrangible edge, the width was over 50 tenth-meters. Assuming 25 tenth-meters as the extreme displacement due to motion, we have

$$V = \frac{\Delta\lambda}{\lambda} v = \frac{25 \times 186{,}000}{5000} = 930 \text{ miles per second.}$$

Taking the round number 1000 miles per second as an extreme velocity and the motion announced in the telegram from Lick Observatory of 1′ in six weeks we have for the distance of the star

$$D = 42 \times 24 \times 3600 \times 1000 \times \cot 1' = 12{,}500{,}000{,}000{,}000 \text{ miles}$$

and for the parallax

$$\pi = \frac{92{,}800{,}000}{D \tan 1''} = 1''.5.$$

If we take the lesser motion of 1′ in 55 days, indicated by our own photographs compared with Ritchey's, we get in the same way a distance of 16 trillions of miles and a parallax of 1″.2. On these assumptions then the star would be only about half as far away as α Centauri and its parallax nearly twice as great. If the motion is less rapid the star must be nearer still. If the star is farther away the motion must be greater. It will be interesting therefore to learn what results are obtained from the measures of photographs taken for the purpose of determining the star's parallax. In a few months from now there should be abundant data at hand.

GENERAL NOTES.

Krakatoa.—Our readers doubtless remember the history of the tremendous volcanic eruptions that took place on this world famous island of Krakatoa in 1883. The views of the island, as it now looks, are shown in very realistic way by the fine photographs of it obtained by Professor Barnard recently. His article gives a full account of the long voyage to Sumatra for the purpose of observing the last total solar eclipse.

The Leonids for 1901.—From brief accounts so far received, it appears that observers who have before been interested, but sadly disappointed, watchers for the Leonid displays of the last two years were, some of them, surprised and largely taken off their guard, when the shower came and found them quite unprepared to observe it most effectively.

The British Association held its annual meeting in Glasgow in September for this year and its attendance was 1900, somewhat smaller than usual. Some of the papers and addresses were remarkable, receiving very favorable comment at the time, and since by scholars in different parts of the world. The communication of greatest popular interest was that given by Lord Kelvin on "The Absolute Amount of Gravitational Matter in any Large Volume of Interstellar Space." In *Nature* of Oct. 24, a full account of this paper is given, and a summary of it more or less full appears in other scientific papers of recent date. In

Nature a full enough account of it is given that the reader may get something of its profound character, and the large questions which Lord Kelvin discusses with wonderful insight and a penetration of thought that put some abstruse things into such clear light that we do not wonder that it aroused a feeling of popular interest that could scarcely have been expected on such a theme from even the most gifted scholars in modern science. It is refreshing to read how he compares the ether of space with ordinary matter, and to notice how and why he relates ether to space as he does, and how ether affects the motion of ordinary matter in space, which he calls gravitational matter, as if there were matter in space that was not influenced by gravitation. That which we have seen of this communication is so clearly presented, and so instructive for those having interest in such lines of study that it ought to have general circulation.

The Eclipse of Thales.

To the Editor of Popular Astronomy.

I beg to offer a very few lines in reference to Professor Stockwell's article in the last number of your valuable journal.

The matter now seems to stand thus, Baily (he was not *Sir* Francis, as both Professor McFarland and Professor Stockwell call him) from the last lunar tables then in use (which were in fact those of Bürg) found that the account of the eclipse which, according to Herodotus, put a stop to an impending battle between the Medes and Lydians, would be best satisfied by taking it to be one which occurred in B. C. 610 on Sept. 30: But he expressed grave doubts as to whether this was the true conclusion, because the same tables made the eclipse of Agathocles in B. C. 310 Aug. 15, not total. By the use of the latter tables Burckhardt Hind came to the conclusion that the eclipse, after called that of Thales, (because he has been said to have predicted it) was really that of B. C. 555 May 28; and Airy, remarking that preference must be given to the more accurate accounts of the eclipse of Agathocles, and after adopting some corrections derived from Greenwich observations, decidedly supported this view, which was also held in a modified and more doubtful form by Professor Newcomb. But now Professor Stockwell states that his own value of the lunar acceleration makes the two eclipses of B. C. 610, Sept. 30 and B. C. 603, May 18 total in Asia Minor and that the eclipse of Agathocles cannot be used in the question, because we are not told at what time of day it occurred.* To decide between the eclipses of 610 and 603, he adds that he has detected two cycles of eclipses shorter than the so-called saros; one of 82 lunations at the same node, and another of 88 lunations at opposite nodes. Now one of the former periods (= 6 years 230 days) elapsed between these two dates; and the suggestion is that Thales observed the former eclipse and, being aware of the said cycles, predicted the latter.

But surely it was a very remarkable coincidence that the shadow in these two eclipses should have passed over so nearly the same locality. It is this that seems to make the prediction of solar eclipses by cycles so difficult, and must have been in the time of Thales, when so small a part of the world was known, impossible; for which reason I was led to reject the notion that the eclipse of B. C. 585 could have been predicted by the lapse of 18.03 years from that of B. C. 603.

* The account in Justin is indefinite indeed and of itself would lead to the impression that the eclipse took place not long before the landing in Africa; that in Diodonus Siculus states particularly that it was on the day after leaving Syracuse.

I have only to add that I do not think anything can be made of the Chinese eclipse in the 22d century B. C., its date being *very* uncertain. Rothman, in *Memoirs of the R. A. S.*, Vol. XI, p. 47, showed that it was most probably on Oct. 13, B. C. 2128, but Professor Stockwell puts it in B. C. 2136, and others earlier still. With regard to the eclipse of A. D. 1140, it does not seem clear that it was total in London. Our principal authority for it is the Anglo-Saxon Chronicle, which I have quoted in my "Remarkable Eclipses." William of Malmesbury indeed says that stars were seen near the Sun in that locality; and one would like to know whether Professor Stockwell's calculations make the shadow pass over that place rather than London. W. T. LYNN.

BLACKHEATH, LONDON, S. E., 1901, Oct. 10.

Orbit of η Cassiopeiæ.—In *Astronomische Nachrichten*, No. 3743, Dr. W. Doberck, of the Hongkong Observatory, gives a new determination of the elements of this star, from observations extending from 1780 to 1900. The period of this binary is quite uncertain, the results ranging from 148 to 328 years. In fact the observations are quite well represented by the parabolic orbit which Dr. Doberck gives as one of several which he tried. He says "..... I varied the elements by degrees and obtained Elements II, which I could not further improve. Then I rejected the observations made previous to 1820 and obtained Elements III, IV, V and VI (all referred to the equinox for 1900) from the modern observations alone, laying weight upon the representation of the distances. The periods vary from 148 years to 327 years. When the period adopted sensibly exceeds the latter value, the distances are not quite represented, although Sir W. Herschel's angles are represented more and more closely the greater the period becomes. I therefore laid a parabola through the positions of the companion for 1835, 1865 and 1890.

"Since Sir John Herschel took up the construction of double star orbits, it has become usual to determine such orbits long before the available observations really allow the true orbit to be known, and this has of late years given rise to some misunderstanding from the side of people, who are not familiar with the subjects. In consequence Professor Thiele has suggested the use of curves, such as certain spirals, not conic sections, but still of a shape that can be adapted closely to the apparent orbit. In analogy with the orbits of comets, I submit it to be preferable to calculate parabolic orbits in future, where the observations are not adequate to fix an elliptic orbit. The procedure would then be as follows: The curves for angles and distances are drawn. The distances are also obtained from the angles by differentiation, and the angles from the distances by mechanical quadrature. "Constant errors" are eliminated and the law of equal areas is satisfied. Next expressions like these are determined:

$$\vartheta_c = a + bt + ct^2, \rho_c = d + et,$$

and as soon as it becomes impossible to represent the observations by these five elements, then a parabola is determined from three complete observations, which are necessary and sufficient for the purpose. When a parabola no longer satisfies the observations, then an elliptic orbit must be determined. In view of remarks made by me in *A. N.* 3519 it is however probable that many double stars move in orbits that are indistinguishable from the parabola.

"Orbit VI must be considered as the definitive orbit, so far, but when at some future time it becomes possible to improve upon the elements by treating equa-

tions of condition according to the method of least squares, the distances, by aid of which the orbit is much more accurately determined than by the observed angles, cannot be left out of account.

ELEMENTS OF THE ORBIT OF η CASSIOPEIÆ.

	II	III	IV	V	VI	Parabola.
	° ′	° ′	° ′	° ′	° ′	° ′
$\Omega =$	57 0	54 42	63 39	68 48	78 48	$\Omega = 120$ 19
$\lambda =$	225 44	230 4	189 13	163 7	131 36	$\lambda =$ 44 51
$\gamma =$	55 16	53 1	41 28	36 35	32 17	$\gamma =$ 41 31
$e =$	0.5092	0.5458	0.3779	0.3692	0.4091	$e = 1.0000$
$P =$	$165^{y}.27$	$148^{y}.46$	$208^{y}.21$	$253^{y}.57$	$327^{y}.87$	$\log n = 0.2619$
$T =$	1912.66	1908.94	1910.30	1905.85	1899.00	$T = 1879.55$
$a =$	8″.41	7″.91	8″.00	8″.49	9″.48	$q =$ 6″.01

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the tenth of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription will hereafter be sent with the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal, promptly as this publication will not be continued beyond the time for which it has been ordered.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should always notify the publisher when the copy is sent or the proof returned. They cannot be furnished later without incurring much greater expense.

Subscription Price to Popular Astronomy in the United States, Canada and Mexico is $2.50 per volume of 10 consecutive numbers. Price per volume of 10 numbers to foreign subscribers $3.00.

All correspondence and all remittances should be sent to

WM. W. PAYNE,
Northfield, Minn., U. S. A.

GENERAL INDEX TO VOLUME IX.

Adjustment of the Equatorial Telescope, On the—II. Kurt Laves..... 13
Aitken, R. G.—Orbit of ζ Sagittarii..... 57
Algebra by Boyd (book review)..... 470
Fisher and Schwatt (book review)..... 470
Algol type, Minima of variable stars of the—..... 572
variable 78.1901 (note)..... 571
Almucantar, The Case—(note)..... 160
Amherst College solar eclipse expedition (note)..... 276
Analytic geometry, Ashton's—(book review)..... 163
Ancient eclipses and chronology, R. W. McFarland..... 176
Anderson, T. D.—New variable in Pegasus (note)..... 49
George, In memory of—(note)..... 350
Anderson's new star in Perseus, Edward C. Pickering..... 184
Annular eclipse of the Sun, Nov. 10 (note)..... 512
Apex of the Sun's way (note)..... 414
Arctowski, H., Translation of article by—..... 207
Are there possible Martians? G. Seneca Jones..... 234
Ashton's Analytic Geometry (book review)..... 163
Asteroid (172) Baucis, Ephemeris of—(note)..... 570
(175) Andromache, Elements and ephemeris—(note)..... 570
(196) Philomela, New elements of—..... 275
(209) Dido, Orbit of—..... 159
(314) Rosalia, Elements of—..... 349
(334) Chicago, Ephemeris of—(note)..... 514
(391) Ingeborg, Ephemeris—.....406, note 459
(444) Gyptis, Ephemeris of—(note)..... 571
(456) 1900 FH, Elements—(note)..... 405
(456) 1900 FH (note)..... 405
notes..... 569
Asteroids at Pulkowa, Observations of—(note)..... 159
discovered, New—(note)..... 569
named (note)..... 405
Naming of—(note)..... 458
Numbering new—(notes).....213, 569
(82), (113), (241) and (247), New elements of—(note)..... 515
1901, FV, FX, FY, Elements of—(note)..... 514
(457) to (463), Elements of—..... 275
Astral geometry, George Bruce Halsted..... 187
Astrographical Observatory, Annals—(note)..... 462
Astronomer's pole, Harold Jacoby..... 177
Astronomical books for the use of students, H. A. Howe.....29, 61, 169, 225
conference held at Paris, Report of—M. M. Loewy..... 393
investigation, The scientific value of photography for—George Clark, M. A..... 294
phenomena during 1901, H. C. Wilson..... 37

Astronomy, Illustrations from—W. W. Payne 151
in the high schools, Inquirer—(note) 279
in the 20th century, by Serviss, (note) 286
New text-book of—by Geo. C. Comstock (book review) 288
Notes on the progress of double star— 161
of the nebulæ, W. W. Payne 490
Atlas of variable stars, Hagen's—(note) 50
Attraction and figure of the Earth, II, III, W. W. Payne 7, 117
August meteors, (note) Robert M. Dole 523
(note) Walter M. Mitchell 522
of 1901 (note) 413
Barnard receives Janssen gold medal (note) 107
E. E., Total eclipse of the Sun in Sumatra 527
Barnes, Willis L., Dark transit of Jupiter's third satellite (note) 411
Bartlett, Arthur K., The wet and dry Moon 442
Besselian star-numbers, 1899-1904, Tables on the—(note) 161
Binary η Pegasi, The orbit of the spectroscopic—(note) 521
stars, Density and figure of close—(note) 461
Board of visitors of U. S. naval Observatory, W. W. Payne, 71; (note) 216
Book reviews 54, 163, 286, 359, 469
Brackett, F. P., Observations of Nova Persei at Pomona College (note) 221
Brenke, W. C., An observational determination of the apparent figure of the sky (note) 351
Observations of Nova Persei (note) 356
Brightness of Nova Persei, H. C. Wilson (note) 409
star-light, J. E. Gore 506
Brooks has chair at Hobart College (note) 50
Morgan, Nova Persei (note) 283
Brown, S. J., Eros observations (note) 50
Bruce photographic telescope (note) 110
Bulletin I, Lick Observatory (note) 163
Bulletins from Lick Observatory (note) 522
Burnham, S. W., Double star notes 105
Hussey's measures of the OΣ double stars 553
Calculus, Ellen Hayes—(book review) 54
Campbell, W. W., Crocker eclipse expedition to Sumatra (note) 221
Determinations of the Sun's distance from observations of Eros 88
Cape of Good Hope Observatory (note) 411
Capella a visual double star, H. C. Wilson (note) 109
Case Almucantar (note) 160
Catalogue of north polar stars, A photographic—Caroline E. Furness 1
Chandler, S. C., Nomenclature of variable stars (note) 219
Chart and catalogue for observing Nova Persei, First—John G. Hagen, S. J., 191; second 280
Chart, Miss Proctor's astronomical—(note) 165
Christian, Isaac E., The Gegenschein 146
Tidal friction and planetary rotations 194
Christianity, Modern science and—(note) 353
Clairaut's Theorie de la Figure de la Terre, Note on—Asaph Hall 60
Clark & Sons corporation, The Alvan—(note) 287

Clark, M. A., George, The scientific value of photography for astronomical investigations 294
Clock by which we set all our watches (note) 162
Coma Berenices, An abstract of a paper on stars in—W. C. Kretz 75
Comet and asteroid notes, H. C. Wilson 159, 213, 404, 558
a 1901, Elements of—(note) 404
Ephemeris of— 348
b 1900 (note) 159
b 1901, Ephemeris of—(note) 405
c 1900, Elliptic elements of— 159
c 1900 (Giacobini), New—(note) 106
1894 I (Denning), Search ephemeris for— 348
1894 II, Definitive orbit of— 348
1898 VII, Definitive orbit elements— 213
1901, 1, Elements of—(note) 513
Ephemeris of Encke's—(note) 513
Hall's—Edgar L. Larkin (note) 352
The new—E. A. Fath 289
Coming opposition of Eros, Mary Clark Traylor 496
Computation of the ephemeris of a planet or a comet, Mary Clark Traylor 311
Comstock's new text-book of astronomy (book review) 288
Consecutive numbers, Rule for squares of—Percival Hall (note) 161
Constellations 42, 101, 157, 212, 274, 345, 401, 455, 510, 568
Cyclones, Eclipse— 204
Cygni, New Algol type variable 78.1901 (note) 571
Davis, Herman S., List of new stars, So-called—(note) 284
Denning, W. F., Motion of the great red spot and other markings on Jupiter 488
Density and figure of close binary stars (note) 461
Description of the medals, Dr. Lewis Swift 505
Detection of nebulæ by photography, Annals of Harvard College Observatory 431
Detroit's different kinds of time, Literary digest— 36
Dido, Orbit of the asteroid (209)— 159
Dole, Robert M., August meteors (note) 523
Meteors during July and August (note) 525
Doolittle, Eric, November meteors at Flower Observatory (note) 53
Double star astronomy, Notes on the progress of— 161
notes, S. W. Burnham 105
stars, Hussey's measures of the OΣ—S. W. Burnham 553
Douglass, A. E., Nova Persei 263
Photographs of the zodiacal light 190
Durfee's elements of trigonometry (book review) 55
Eadie, John H., Visibility of Mercury (note) 462
Earth, Attraction and figure of the—II, III, W. W. Payne 7, 117
not a globe (note) 164
Earthquakes, Frequency of—(note) 164
η Cassiopeiae, Orbit of—(note) 578
Eclipse cyclones 204
expedition, Amherst college solar—(note) 276
to Sumatra, Crocker—W. W. Campbell (note) 221
May 17-18, 1901, Total solar—H. C. Wilson 267

Eclipse of Thales, W. T. Lynn (note) ... 577
of the Sun, Nov. 10, Annular—(note) ... 512
party from Washington (note) ... 222
phenomenon, A new—J. F. Lanneau ... 67
photography, extract ... 165
predicted by Thales, John N. Stockwell ... 376
Eclipses and chronology, Ancient—R. W. McFarland ... 176
of the Sun teach us, What—David P. Todd ... 305
Elements and ephemeris of asteroid (172) Baucis (note) ... 570
(175) Andromache (note) ... 570
comet *a* 1901 ... 404
of asteroid (456) 1900 F. H. (note) ... 405
(196) Philomela, New— ... 275
(457) to (463) ... 275
asteroids (82), (113), (241) and (247), New—(note) ... 515
1901, FV, FX, FY (note) ... 514
comet 1901 I (note) ... 513
planet (454), Mathesis—(note) ... 514
Encke's comet, Ephemeris of—(note) ... 513
periodic comet, E. L. Larkin (note) ... 405
Energy curves and line spectrum from bolographs, Plate XIV, opposite ... 45
Ephemeris of a planet or a comet, The computation of the—Mary Clark Traylor ... 311
asteroid (391) Ingeborg (note) ... 406, 459
(444) Gyptis (note) ... 571
comet *b* 1901 ... 405
Encke's comet (note) ... 513
the asteroid (334) Chicago (note) ... 514
Equatorial, C. A. Posts'—for meteor photography, Plate II, opposite ... 79
telescope, On the adjustment of—II, Kurt Laves ... 13
Equipment of Harvard College Observatory (note) ... 111
Erratum, W Lyrae for U Lyrae ... 572
Eros a double planet? H. C. Wilson (note) ... 277
and the solar parallax (note) ... 465
at Northfield, Observations of—(note) ... 167
the University of Minnesota, Photographs of—(note) ... 168
Campaign, Pres. Loewy's bulletin No. 7 of—H. C. Wilson ... 214
Ephemeris of—Mary Clark Traylor ... 358
observations, Determinations of Sun's distance from—W. W. Campbell 88
S. J. Brown (note) ... 50
of—H. C. Wilson ... 108
Subject of letter from—M. Loewy (note) ... 107
The coming opposition of—Mary Clark Traylor ... 496
U Persei and—(note) ... 515
Variability in the light of—Edward C. Pickering ... 290
of—(note) ... 213
Variation in light of—Edward C. Pickering (note) ... 358
Evanescent star photographs (note) ... 223
Fath, E. A., The new comet ... 289
Figure of the Earth, Attraction and—II, III, W. W. Payne ... 7, 117
sky, An observational determination of—W. C. Brenke (note) .. 351

Fire-ball of Dec. 7, 1900, Lela Lorena Stingley..... 426
The great—H. A. Howe (note)..... 107
Fisher & Schwatt's, algebra (book review)..... 470
Floating telescope (note)..... 349
Frequency of earthquakes (note)..... 164
Furness, Caroline E., A photographic catalogue of north polar stars..... 1
Gegenschein, The—Isaac E. Christian..... 146
General notes, W. W. Payne.....50, 107, 160, 216, 275, 349, 411, 462, 520, 576
perturbations and the perturbative function, J. Morrison, M. A., M. D., Ph. D.....130, 249, 436
Geneva, Latitude of Observatory of—(note)..... 162
Geometry and astronomy, Non-euclidean—W. H. S. Monck..... 370
Astral—George Bruce Halsted..... 187
Supplementary report on non-Euclidean—George Bruce Halsted... 555
Gore, J. E., The brightness of star-light..... 506
Gould fund, The B. A.—Boss, Chandler, Hall, committee..... 276
Greenwich second ten-year catalogue (note)..... 463
Hadden, David E., Observations of Nova Persei (notes)..... 282, 355
Hagen, S. J., John G., First chart and catalogue for observing Nova Persei.. 191
Hagen's atlas of variable stars (note)..... 50
Hale, George E., New star in Perseus..... 264
Hall, Asaph, Note on Clairaut's theorie de la figure de la Terre..... 60
Note on multiplication..... 31
Halsted, George Bruce, Astral geometry..... 187
Supplementary report on non-Euclidean geometry.... 555
Harvard College Observatory equipment (note)..... 111
Harvey, Arthur, Study of terrestrial magnetism (note)..... 467
Hayes, Ellen, Calculus (book review)..... 54
Helsingfors photographic instrument, Plate VI, opposite..... 181
Hisgen, S. J., Jos., New variable star Cygni (note)..... 48
Holmes, Edwin, The limits of vision..... 499
Howard, Charles P., Total eclipse of the Sun..... 18
Howe, H. A., Astronomical books for the use of students.....29, 61, 169, 225
Note on "Pleasures of the telescope"..... 286
The great fire-ball (note)..... 107
Hudson bay, Leonids seen at—(note)..... 162
Hussey's measures of the OΣ double stars, S. W. Burnham..... 553
Illustrations from astronomy, W. W. Payne..... 151
In memoriam to George Anderson (note)..... 350
Innes, R. T. A., On interpolation..... 389
Instruments of Tycho Brahe at the Prague Observatory, H. C. Wilson..... 113
Plate, III, opposite..... 113
Interpolation, On—R. T. A. Innes..... 389
Jacoby, Harold, The astronomer's pole..... 177
Janssen gold medal awarded to Barnard (note)..... 107
Jones, George L., Observations of variable star 7609 T Cephei (note)..... 408
Nova Persei (note)..... 573
G. Seneca, Are there possible Martians?..... 234
Visibility of Mercury..... 367
Jupiter, Motion of the great red spot and other markings on—W. F. Denning 488
Visibility of the satellites of—(note)..... 441

Jupiter's third satellite, Dark transit of—Willis L. Barnes (note)..... 411
Kretz, W. C., Abstract from paper on stars in Coma Berenices..... 75
Langley, S. P., The new spectrum..... 415
Lanneau, J. F., A new eclipse phenomenon..... 67
Larkin, Edgar L., Comet Halls (note)..... 352
Encke's periodic comet (note)..... 405
Mount Lowe Railway Observatory..... 359
Latitude of Observatory of Geneva (note)..... 162
Laves, Kurt, On the adjustment of the equatorial telescope, II..... 13
Lawton, Geo. K., T. J. J. See Plate XIII, opposite..... 374
Leonid meteors (note)..... 521
Leonids at Pomona College (note)..... 50
for 1901, W. W. Payne..... 559
seen at Hudson bay (note)..... 162
Lick Observatory, bulletin I, II (notes).....163, 412
bulletins (note)..... 522
Light curve of new star in Perseus, H. C. Wilson.....447, 479, 545
Nova Persei, Plate XV, opposite..... 471
Limits of vision, The—Edwin Holmes..... 499
Loewy, M. M., Report of astronomical conference held at Paris..... 393
writes director U. S. N. Observatory (note)..... 107
Loewy's bulletin No. 7 ot Eros campaign, H. C. Wilson..... 214
Long exposure photographs (note)..... 413
Lynn, W. T., The eclipse of Thales (note)..... 577
Magnetism, Study of terrestrial—Arthur Harvey..... 467
Martians? Are there possible—G. Seneca Jones..... 234
Mars, Projection from limb of—(note)..... 50
Mathesis, Elements of planet (454)—(note)..... 514
Maxima and minima of variable stars..... 573
not of the Algol type (note)..... 517
of U Pegasi.....517, 573
McFarland, R. W.—Ancient eclipses and chronology..... 176
Medals given to Dr. Swift, Description of the—Lewis Swift..... 505
of Dr. Swift, Plate XVI opposite..... 505
Meteors, August—Robert M. Dole (note)..... 523
during July and August, Robert M. Dole (note)..... 525
for 1901, August—(note)..... 413
Leonid—(note)..... 521
Observations of November—J. K. Rees..... 79
Observations of Perseid—(note)..... 463
The August—Walter M. Mitchell..... 522
Mercury, Visibility of—G. Seneca Jones..... 367
Micou, R. D.—Observations of Nova Persei (note)..... 356
Minima of variable stars of the Algol type.....104, 460, 516, 572
Mitchell, Walter M.—The August meteors (note)..... 522
Monck, W. H. S.—Non-Euclidean geometry and astronomy..... 370
Moon and wet days (note)..... 464
The wet and dry—Arthur K. Bartlett..... 442
Morrison, M. A., M. D., Ph. D., J.—General perturbations and the perturbative function.....130, 249, 436
Motion of the great red spot and other markings on Jupiter, W. F Denning.. 488

Mount Lowe railway Observatory, Edgar L. Larkin..... 359
views, Plate XII, opposite..... 366
Multiplication, Note on—Asaph Hall..... 31
Naming of asteroids (note)..... 458
Nature of solar corona (note)..... 112
Naval Observatory clock does not control all time in states (note)..... 162
visitors, Report on the—..... 563
Nebulæ by photography, Discovery and cataloguing of small—(note)..... 468
detected by photography, Annals of—Harvard College Observatory. 431
The astronomy of the—W. W. Payne..... 490
New asteroids discovered (note)..... 569
comet, The—E. A. Fath..... 289
star in Perseus, George E. Hale..... 264
The—H. C. Wilson..... 197
stars, List of—Herman S. Davis (note)..... 284
variable in Pegasus, T. D. Anderson (note)..... 49
star Cygni, Jos. Hisgen, S. J. (note)..... 48
in Lyra, A. Stanley Williams (note)..... 49
76-1901 (Ophiuchi) (note)..... 407
κ (74.1901) Persei (note)..... 407
75.1901 (36 Fl.) Persei (note)..... 407
stars (note)..... 407
volume, new year, new century, W. W. Payne..... 32
Nineteenth century, Scientific progress during—"Knowledge Diary".....91, 128
Nipher, Francis E., Positive photography with special reference to eclipse work..... 24
Non-Euclidean geometry and astronomy, W. H. S. Monck..... 370
Supplementary report on—George Bruce Halsted.... 555
Northern and southern lights illuminating the heavens at the same time, translation..... 207
Northfield, Observations of Eros at—(note)..... 167
North polar stars, A photographic catalogue of—Caroline E. Furness..... 1
Nova Persei, A. E. Douglass..... 263
chart I, John G. Hagen, S. J..... 192
Edward C. Pickering, 184; (note)..... .....282, 407
George E. Hale..... 264
H. C. Wilson..... 197
Morgan Brooks (note)..... 283
Wm. E. Sperra (note)..... 284
at Alta, Iowa, Observations of—David E. Hadden (note)..... 282
Ladd Observatory, Observations of—Winslow Upton (note) 220
Pomona College, Observations of—F. P. Brackett (note)..... 221
Poughkeepsie, Observations of—Mary E. Whitney (note)..... 220
Seagrave Observatory, Observations of—(note)..... 217
University of Virginia, Observations of—R. D. Micou and C. P. Olivier (note)..... 356
Yerkes Observatory, Observations of—J. A. Parkhurst (note) 218
Brightness of—H. C. Wilson (note)..... 409
First chart and catalogue for observing—John G. Hagen, S. J... 191
Mira, R. O'Halloran (note)..... 410
(note) 575

Nova Persei, Observations of—F. E. Seagrave (note)....283, 519
David E. Hadden (note).... 355
G. L. Jones (note).... 573
Mary E. Whitney.... 574
Rose O'Halloran (note).... 354
W. C. Brenke (note).... 356
Second chart and catalogue for observing—John G. Hagen, S. J. 280
The brightness of—Anne Sewell Young (note).... 357
November meteors at Flower Observatory, Eric Doolittle (note).... 53
in 1898, 1899 and 1900, J. K. Rees.... 79
Numbering new asteroids (notes)....213, 569
Obituary, Geo. K. Lawton, T. J. J. See.... 374
notices....161, 374
Observations of Eros, H. C. Wilson.... 108
of Nova Persei, George L. Jones (note).... 573
Mary E. Whitney (note).... 574
of November meteors in 1898, 1899, 1900, J. K. Rees.... 79
of variable star 7609 T Cephei, George L. Jones, (note).... 408
Occultations visible at Washington.....46, 102, 159, 212, 274, 346, 458, 511, 569
Observatory, Helsingfors—Plate V opposite.... 180
The oldest European (note).... 525
Observing variable stars, Co-operation in—Edward C. Pickering.... 148
O'Halloran, Rose, Observations of Nova Persei (note).... 354
New variable in Perseus (note).... 518
Nova Persei, Mira (note).... 410
Sunspot observations (note).... 412
U Lyrae (note).... 518
U^3 Cygni (note).... 518
Oldest European Observatory (note).... 525
Olivier, C. P., Observations of Nova Persei (note).... 356
Observations of the Perseids (note).... 525
On interpolation, R. T. A. Innes.... 389
Orbit of the spectroscopic binary η Pegasi (note).... 521
comet *a*, 1901, Plate VIII opposite.... 289
η Cassiopeiae (note).... 578
ζ Sagittarii, R. G. Aitken, Plate I, opposite.... 57
Parkhurst, J. A., Observations of Nova Persei at Yerkes Observatory (note). 218
Notation of new variables (note).... 219
Variable stars....48, 104
Parallax, Eros and solar—(note).... 465
Payne, W. W., Attraction and figure of the Earth, II, III....7, 117
Board of visitors of U. S. Naval Observatory.... 71
General notes....50, 107, 160, 216, 275, 349, 411. 462, 520
Illustrations from astronomy.... 151
New volume, new year, new century.... 32
Publisher's notices....56, 112, 224, 288, 359, 579
The astronomy of the nebulae.... 490
The Leonids for 1901.... 559
Things of present interest in astronomy.... 445
Perseid meteors charted, C. P. Olivier.... 526
Robert M. Dole.... 523

Perceid meteors, Observations of—(note) 463
Perseids, 1901, Observations of—Charles P. Olivier (note) 525
Perseus, Light curve of new star in—H. C. Wilson 447, 479, 545
New variables in—Rose O'Halloran (note) 518
Perturbations and the perturbative function, General—J. Morrison, M. A., M. D., Ph. D. 130, 249, 436
Phases of the Moon 102, 159, 211, 273, 346, 456, 511, 569
Phenomena of Jupiter's satellites, H. C. Wilson 346, 402, 456
Phenomenon, New eclipse—J. F. Lanneau 67
Photographic search for periodic comets (note) 406
telescope, The Bruce—(note) ..... a 110
Photographs, Evanescent star—(note) 223
Long exposure—(note) 413
of the zodiacal light, A. E. Douglass 190
Photography, Eclipse—(extract) 165
for astronomical investigations, The scientific value of—George Clark, M. A. 294
with special reference to eclipse work, Positive—Francis E. Nipher 24
Pickering, Edward C., Anderson's new variable in Perseus 184
Co-operation in observing variable stars 148
Nova Persei (note) 282
No. 2 (note) 407
Spectrum of ζ Puppis (note) 222
Variability in the light of Eros 290
Variation in the light of Eros (note) 358
Planet notes, H. C. Wilson 101, 156, 211, 273, 344, 401, 455, 510, 567
Pleasures of the telescope, H. A. Howe (note) 286
Planetary rotation, Tidal friction and—Isaac E. Christian 194
Pole, The astronomer's—Harold Jacoby 177
Pomona College, Leonids at—(note) 50
Positive photography with special reference to eclipse work, Francis E. Nipher 24
Prague Observatory, Instruments of Tycho Brahe at the—H. C. Wilson 113
Preliminary investigations of the probable diameters, masses and densities of those satellites which have measurable discs, T. J. J. See 471
Proctor's astronomical chart (note) 165
Projection from limb of Mars (note) 50
Publisher's notices, W. W. Payne 56, 112, 224, 288, 359, 579
Pulkowa, Observations of asteroids at—(note) 159
ζ Puppis, Spectrum of—Edward C. Pickering (note) 222
Railway to Mount Lowe Observatory, Plate IX, opposite 359
Ratio of progression in the number and the light of the stars (note) 466
Reed, Taylor, Spectroscopic notes 47, 99, 153, 209, 344
Rees, J. K., Observations of November meteors in 1898, 1899, 1900 79
Re-organization of the U. S. Naval Observatory (note) 162
ζ Sagittarii, Orbit of—R. G. Aitken 57
Satellites of Jupiter, Visibility of—(note) 414
which have measurable discs, Preliminary investigations of the probable diameters, masses and densities of these—T. J. J. See. 471
Schuster on Kayser's Hand-buch der spectroscopie (note) 163

Science and Christianity, Modern—(note) 353
Scientific progress during the nineteenth century, "Knowledge Diary" 91, 128
Scott, Foresman & Company's new algebra (book review) 469
Seagrave, F. E., Observations of Nova Persei (notes) 217, 283, 519
See, T. J. J., Death of Geo. K. Lawton 374
Preliminary investigations of the probable diameters, masses and densities of those satellites which have measurable discs 471
Serviss' "Astronomy in the 20th century" (note) 286
Short period not of Algol type, Variable stars of—(note) 571
Solar corona, Nature of—(note) 112
Spectroscopic notes, Taylor Reed 47, 99, 153, 209, 343
Spectrum of Nova Persei, Plate VII, opposite 225
ζ Puppis, Edward C. Pickering (note) 222
The new—S. P. Langley 415
Sperra, Wm. E., Nova Persei (note) 284
Squares of consecutive numbers, Rule for—Percival Hall (note) 161
SS Cygni, Note on— 48
Starlight, The brightness of—J. E. Gore 506
Stars, Ratio of progression in the number and light of the—(note) 466
Stellar astronomy, An introduction to—(book review) 359
Stingley, Lela Lorena, Great fireball of Dec. 7, 1900 426
Stockwell, John N., On the eclipse predicted by Thales 376
Students, Astronomical books for the use of—H. A. Howe 29, 61, 169, 225
Sun and his system (extract) 123
in Sumatra, Total eclipse of the—E. E. Barnard 527
Total eclipse of the—Charles P. Howard 18
Sun's distance from Eros observations, Determinations of—W. W. Campbell. 88
Sunspot observations, Rose O'Halloran (note) 412
Sunspots during 1900 (note) 463
Sun's way, Apex of—(note) 414
Swazey, On observational astronomy, Godwin D.—(note) 521
Swift, Dr. Lewis, Description of medals 505
Ups and downs and here and there of an astronomer 476
Swift's equipment sold, Dr. Lewis—(note) 224
Telescope, A floating—(note) 349
Tercentenary of Tycho Brahe's Death, from *Nature* 565
Thales, On the eclipse predicted by—John N. Stockwell 376
The Gegenschein, Isaac E. Christian 146
new spectrum, S. P. Langley 415
Things of present interest in astronomy, W. W. Payne 445
Tidal friction and planetary rotations, Isaac E. Christian 194
Todd, David P., What eclipses of the Sun teach us 305
Total eclipse of the Sun, Charles P. Howard 18
in Sumatra, E. E. Barnard 527
Traylor, Mary Clark, Ephemeris of Eros 358
The coming opposition of Eros 496
The computation of an ephemeris of a planet or a comet 311
Trigonometry, Durfee's elements of—(book review) 55
Tycho Brahe's death, Tercentenary of—from *Nature* 565
U^3 Cygni, Rose O'Halloran (note) 518

U Lyrae, Rose O'Halloran (note) 518
University of Minnesota, Photographs of Eros at—(note) 168
U Pegasi, Maxima of— 517, 573
U Persei and Eros (note) 515
Ups and downs and here and there of an astronomer—Lewis Swift 476
Upton, Winslow, Observations of Nova Persei at Ladd Observatory (note) .. 220
U. S. Naval Observatory, Board of visitors for—(note) 216
of—W. W. Payne 71
legislation (note) 217
More trouble at—(note) 216
(note) 166
Re-organization of—(note) 162
Visit of board of visitors to—(note) 350
U Virginis, Edward C. Pickering 148
Variable η Argus (note) 411
Variables, Notation of new—J. A. Parkhurst (note) 219
Variable star 77, 1901 Herculis, New—(note) 515
7609 T Cephei, George L. Jones (note) 408
stars 407, 459, 515, 571
Co-operation in observing—Edward C. Pickering 148
J. A. Parkhurst 48, 104
Maxima and minima of— 573
Nomenclature of—S. C. Chandler (note) 219
of short period not of the Algol type 517, 571
Variability in the light of Eros, Edward C. Pickering 290
of Eros (note) 213
View from Mount Lowe Observatory, Plate X opposite 335
of Mount Lowe Observatory, Plate XI opposite 365
Views on Sumatra eclipse expedition, Plates XVII-XXV, pp 527-545
Visibility of Mercury, G. Seneca Jones 367
John H. Eadie (note) 462
Vision, The limits of—Edwin Holmes 499
Visitors' report on the Naval Observatory 563
Washington, Eclipse expedition from—(note) 222
Wet and dry Moon, Arthur L. Bartlett 442
days, The Moon and—(note) 464
What eclipses of the Sun teach us, David P. Todd 305
Whitney, Mary E., Observations of Nova Persei at Poughkeepsie (note) .220, 574
Williams, A. Stanley, New variable star in Lyra (note) 49
Wilson, H. C., Astronomical phenomena during 1901 37
Brightness of Nova Persei (note) 409
Bulletin No. 7 on Eros campaign from Pres. Loewy 214
Capella, a visual double star (note) 109
Comet and asteroid notes 159, 213, 513, 569
Eros a double planet? (note) 277
Instruments of Tycho Brahe at the Prague Observatory 113
Light curve of the new star in Perseus 447, 479, 545
Observations of Eros 108
Phenomena of Jupiter's satellites 346
Planet notes 101, 156, 211, 273, 344, 401, 455, 510, 567
The new star in Perseus 197
Total solar eclipse of May 17-18, 1901 267
Variable stars 571
Young, Anne Sewell, The brightness of Nova Persei (note) 357
Death of Mrs. Augusta Mirer—(note) 161
Zodiacal light photographs, A. E. Douglass 190
Plate IV opposite 169